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NUMBER AND THE QUADRATIC.

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When a pupil takes up the study of quadratics he is supposed to be familiar with the six arithmetical operations and the rules for their application, viz. addition, subtraction, multiplication, division, involution, and evolution. The seventh operation, viz. the taking of logarithms, he does not become familiar with till he reaches more advanced algebra or possibly till he takes up the study of trigonometry.

As he has advanced from the notion of counting and the allied notion of adding successively, probably not always as successfully as might be wished, through the other operations, he has, perhaps unconsciously, extended or enlarged the field or kinds of numbers. Taking it for granted that he knows something of number, it has seemed to the writer that after the pupil has learned something of the machinery of the quadratic, such as solving by factoring, by completing the square, and particularly by using the formula (A) $x = \frac{-b \pm \sqrt{b^2-4ac}}{2}$ for the equation $ax^2+bx+c = 0$, it would be most profitable to stop long enough to review this number field, not in an exhaustive manner perhaps, and study its growth through the successive operations in turn. It might be that the senior year of the high-school course would be a suitable time.

Having surveyed the number domain from positive integers to the complex number, the writer would suggest that many quadratic equations with rational coefficients be solved from the point of view of the kinds of numbers which these roots are. The solving of simultaneous quadratic equations should be included. Equations with a parameter may be used in order to compel the student to make constant application of the three conditions for the character of the roots, viz. *real* and *equal, real* and *distinct*, and *imaginary*.

And while the writer does not favor the use of the graph in earlier algebra as much as some algebras devote to it, he would urge the use of the *plat* or *graph* of $y = ax^2 + bx + c$ at this point of time and maturity to illustrate the geometric meaning of real and equal roots, real and unequal roots, and imaginary roots, viz. the x-axis as a tangent, as a secant, or as an external.

A child, say eight years old, is doing number work, she is doing the "ands," the "take aways," the "times," and the "how manys." That is, she is learning addition, subtraction, multiplication, and division, but all her work is confined to positive integers, and necessarily so. For she would be no better off than the uncivilized child, were it not for the priceless advantage of the civilized and enlightened environment which is her heritage. As the race began by counting, so does she. Investigators tell us that there have been uncivilized and barbarous races that could not count beyond 3, and some not beyond 2. (The forest tribes of Brazil are an illustration of this fact.) These tribes have no word in their language for numbers beyond 2 and 3, save the word for many. Some tribes, however, are quite proficient in counting, for instance, the natives of Madagascar. It is a well known fact that the natives of the island, a century or more ago, would represent the number composing the army of the enemy by having the natives pass through a passage each depositing a stone until there were 10; a stone was then set aside. After setting aside 10 stones to represent 10 piles, or 100 men, a stone was then set aside in a new position to represent 100, and so on.

Just how the number concept originated in the mind of man is perhaps a fruitless question. Professor Conant in his book on the *Number Concept,* after reviewing the labors of different investigators in this field of speculation says, "The origin of number would in itself, then, appear to be beyond the proper limits of inquiry; and the primitive conception of number to be fundamental with human thought." For in all languages that have been studied, there has always been found some notion of number or quantity.

Is it not true that most of the pupils in quadratics work simply to get the answer, verified by the answer book or by substitution back in the original equation, or by comparison with his classmates? This is allowable, of course, for we must not forget that we are laboring with immature minds. But on the other hand might it not impart more zest to the work if the pupil had some

meaning given these answers when he gets them and make him feel that the onus is on him to fit the meaning?

The writer has had freshmen who had studied the arithmetical and geometrical progressions in secondary schools but who had *not* recognized the fact that *n*, the number of terms in both these series, must be a positive integer. In answer to the question, "*What is a real number?*" the following replies, among others, have been received: "*Those that are rational,*" and "*Positive and negative integers and fractions.*" Both of these answers were the same in thought, and yet both are incomplete.

Let us review the arithmetical processes or operations and discover how the inverse operation introduces a new kind of number.

ADDITION.

The child advances from counting to addition when he has learned such facts as this, viz. that four (4) things and three (3) things make a group of seven (7) things. And by repeated combinations he arrives at other and larger integers. It is evident, too, that as the child advances in addition, his notion of likenesses and differences is developing and that his sense of aggregation is an important item. As these fundamental ideas develop, he is acquiring some conception of the abstract number in contrast with the notion of concrete number.

In these days, how we would be handicapped were we restricted to the positive integer system, 1, 2, 3, 4, 5, 6, etc.! However, this might be mathematical heaven for those pupils who despise fractions.

SUBTRACTION.

The inverse of addition introduces a new kind of number and also a *single* new number when we attempt to subtract a number from a smaller one or to subtract a number from its equal. If the subtractive number is always the smaller, the results will be *positive integers*. The difference of two equal numbers is, we now say, zero or nothing, and is denoted by the symbol o or cipher, which has been in use for the last two or three centuries. But when the subtractive number is the larger, we arrive at the system of negative integers.

In passing it will be interesting to note that Professor Whitehead pays the German scholars a very high compliment in his book, *Introduction to Mathematics*, where he says, "It was the practical man himself who first employed the actual symbols +

and —. Their origin is not very certain, but it seems most probable that they arose from the marks chalked on chests of goods in German warehouses, to denote excess or defect from some standard weight. The earliest notice of them occurs in a book published at Leipzig in A. D. 1489. "There is an old epigram which assigns the empire of the sea to the English, of the land to the French, and of the clouds to the Germans. Surely it was from the clouds that the Germans fetched + and —; the ideas which these symbols have generated are much too important for the welfare of humanity to have come from the sea or from the land."

In the addition of positive integers, the order of combining is immaterial. For evidently 4 and 3 make 7 as well as do 3 and 4. So we arrive by inspection and by intuition at the *commutative law* of addition. Similarly, by inspection and intuition in counting we arrive at the *associative law* of addition which is expressed by the sums $3+4+5=3+(4+5)=(3+4)+5=(3+5)+4$.

These laws become most important when applied to *evolution* and the *taking of logarithms,* by forming an impassable barrier to the extension of the number field of arithmetic.

Multiplication.

If, when performing addition, the quantities to be summed are all equal, we arrive at the operation of multiplication by observing the name of the individual quantity and noting the number of times it occurs. Thus multiplication is abbreviated addition. But in the application of the rules for multiplication we obtain no new numbers other than the positive and negative integers and zero.

In this operation, the *commutative* and *associative* laws hold, as the following illustrations show: $3\cdot 5\cdot 7=3\cdot 7\cdot 5=7\cdot 3\cdot 5$, and $(3\cdot 5)\cdot 7=3\ (5\cdot 7)=(3\cdot 7)\cdot 5$.

We may use symbols for the numbers, which may represent either positive or negative integers; then $a\cdot b\cdot c=a\cdot c\cdot b=c\cdot a\cdot b$, and $a\cdot b\cdot c=(a\cdot b)\cdot c=a\cdot(b\cdot c)=(a\cdot c)\cdot b$.

Division.

The child in the second grade performs divisions with positive integers such that one integer is the multiple of the other. But when the dividend is not a multiple of the divisor, we arrive at the new kind of number called common or vulgar fractions. These all lie somewhere in between integers, so that we not only have more numbers to operate with, but the number system is

made more compact. The field now includes positive and negative integers and fractions, as well as zero.

INVOLUTION.

If we multiply two or more equal quantities together, we arrive at a still further abbreviation of abbreviated addition, for instance, $a \cdot a \cdot a$ we denote by a^3. And we term abbreviated multiplication, involution.

In this operation we see at once that the *commutative* and *associative* laws do not hold. For 2^3 is evidently not the same as 3^2 and 2^{3^4} is not the same as (2^3) raised to the 4th power, since $2^{3^4} = 2^{81}$ and $(2^3)^4 = 2^{12}$.

Here again, we do not arrive at any new kind of number other than the kinds already defined.

EVOLUTION AND THE TAKING OF THE LOGARITHMS.

There are two inverses to addition, that is, we may subtract from the minuend the subtrahend to get the remainder, or we may take the remainder from the minuend to obtain the subtrahend.

Similarly there were the two inverses to multiplication. The dividend divided by the divisor gives the quotient, or the dividend divided by the quotient gives the divisor.

We shall also find two inverses to involution.

The problem, in taking the cube root of 27 or of 125, is to find the three equal factors whose product equals 27 or 125. In this case, the factors, 3 and 5, are easily arrived at. But when we attempt to take the cube root of 17, say, it is impossible to find the three equal factors that compose 17, if these factors are to be expressed as members of the number system already defined. Hence the origin of the ***surd***. The even root of a negative quantity is defined as ***imaginary***. Thus we have reached the two classes of irrational numbers, by applying the inverse of ***involution,*** which we call ***evolution***.

Professor Schubert calls addition and its inverses, subtraction, operations of the first degree, and multiplication and its inverses, division, operations of the second degree, while involution with its inverses, evolution and the taking of logarithms, are operations of the third degree.

In operations of the first degree, the two inverses are practically the same process, the only difference being that differently named quantities are obtained; and similarly for the operations of the second degree, the inverses are the same process, obtaining different quantities; but in operations of the third degree, the

inverses are quite distinct. The difference between *evolution* and *the taking of logarithms* is this: In the former we seek the number affected by the exponent, such as $x^3 = 27$, while in the latter we seek the exponent such as $5^x = 13$. The value of x in the first example is 3 and x in the second example is found from $x \log {}_{10}5 = \log {}_{10}13$ or $x = 1.593+$.

We have now reached the final limit of the number field for arithmetic, having reached it twice previously, viz., after addition and its inverses, subtraction, and after multiplication and its inverses, division.

Question: Are there operations of the fourth degree that will yield other numbers than those already defined? We quote from Professor Schubert's book: "As a matter of fact, mathematicians have asked themselves this question and investigated the direct operation of the fourth degree, together with its inverse processes. The result of their investigations was, that an operation which springs from involution as involution sprang from multiplication is incapable of performing any real mathematical service; the reason of which is, that in involution the laws of commutation and association do not hold."

We next define the numbers which may be found as *roots* of the quadratic equation with integral coefficients. *Definition:* A root of an equation in x is a quantity which when substituted for x in the equation will make the two members of the equation identical.

Example: The number, —1, is a root of $x^3+2x^2 = -2x-1$, for $-1+2 = 2-1$.

The following definition is usually given: A *root* of an equation is a quantity which satisfies the equation. This is perfectly clear to us as teachers, but the writer has been obliged a great many times to explain the word, "satisfies," to pupils who apparently had a serious difficulty just here. The student as a rule is quite familiar with the idea of substitution, but the notion of satisfying an equation is new to most students at this point of mathematical maturity. Hence, the writer's preference for the former definition.

Quadratic Surds.

A quadratic *surd* is the indicated root of a quantity not a perfect power.

An *entire surd* is obtained when none of the factors of the radicand are perfect squares, e. g., $\sqrt{3 \cdot 5 \cdot 7}$.

A *mixed surd* is obtained when one or more (but not all) of the factors of the radicand are perfect squares, e. g., $\sqrt{9 \cdot 16 \cdot 7} = 12\sqrt{7}$.

A *binomial or compound surd* is formed by taking the sum or difference of two unlike surds or of a rational quantity and a surd, e. g., $\sqrt{2} \pm \sqrt{3}$, $5 \pm 3\sqrt{7}$.

IMAGINARIES.

An *imaginary number* is defined as the even root of a negative quantity.

A *pure imaginary* is a number consisting only of the imaginary part, e. g., $\sqrt{-7}$, $5\sqrt{-2}$.

A *complex number* is formed when an imaginary number is added to or subtracted from a rational number or a surd, e. g., $3+\sqrt{-5}$.

A pair of pure imaginaries or a pair of complex numbers are said to be *conjugate* when they differ only in the algebraic sign of the imaginary part, e. g., $3 \pm \sqrt{-5}$.

We may speak of a pair of surds in the same sense; that is, we shall call a pair of surds, *conjugate,* when they differ only in the algebraic sign of one of the surd parts, e. g., $\pm\sqrt{5}$, $5\pm\sqrt{3}$, $\sqrt{7} \pm \sqrt{11}$.

In solving the quadratic, $ax^2+bx+c=0$, by formula (A),

$$x = \frac{-b\pm\sqrt{b^2-4ac}}{2a}$$

the pupil will soon learn that he cannot get a surd and an imaginary as roots of the same quadratic.

A surd will occur only when the *discriminant,* b^2-4ac, is positive, and not a perfect square, and there must be a conjugate pair owing to the *plus* and *minus* sign preceding the radical.

An imaginary will occur only when the *discriminant* is negative, and similarly there must be a conjugate pair.

It is evident that entire or mixed surds and pure imaginaries will occur only as roots of the pure quadratic, since b then equals zero, and that binomial surds and complex numbers will occur as roots of the affected quadratic.

When these facts of conjugate pairs in the solution of the quadratic are once thoroughly learned, it will be an easy matter to teach in the theory of equations that quadratic surds and imaginaries occur in conjugate pairs, and that an equation of odd degree must have at least one root not imaginary.

All the numbers thus far defined, except imaginaries, are spoken of as *real.*

Surds and imaginaries are called *irrational* and the others, *rational.*

Let us use the following schemes to exhibit the number field, each table being constructed for a different viewpoint. Let the pupil see the field as a whole and its subdivisions.

- Numbers
  - Operations of the 1st degree
    - Positive, Negative: Integers, Zero
  - 2nd degree
    - Positive, Negative: Fractions
    - and the preceding
  - 3rd degree
    - Irrational
      - Surds
      - Imaginaries
    - and the preceding

- Numbers
  - Rational
    - Positive, Negative: Integers, Fractions
    - Zero
  - Irrational
    - Surds
    - Imaginaries

- Numbers
  - Real
    - Positive Integers
    - Negative Integers
    - Zero
    - Positive, Negative: Fractions
      - Common
        - Proper
        - Improper
      - Decimal
        - Terminating
        - Non-terminating
        - Repeating
    - Surds
      - Entire, Mixed, Binominal: Conjugate
  - Imaginary
    - Pure, Complex: Conjugate

The following examples when solved illustrate the kinds of number defined.

1. $x^2-7x+6=0$.
2. $x^2+7x+10=0$.
3. $x^2+5x=0$.
4. $12x^2-17x+6=0$.
5. $15x^2+19x+6=0$.
6. $6x^2+11x-5=0$.
7. $x^2-3=0$.
8. $4x^2-5=0$.
9. $x^2+6x+2=0$.
10. $x^2+18=0$.

11. $x^2+6x+84=0$.
12. $x^2-3x=0$.
13. $x^2=0$.
14. $x^2-5x-6=0$.
15. $x^2+6x+9=0$.
16. $x^2-6x+9=0$.
17. $x^2-6x+84=0$.

CHARACTER OF THE ROOTS.

$$x=\frac{-b+\sqrt{b^2-4ac}}{2a}.$$

(1) Real and distinct if $b^2-4ac>0$. Rational if $b^2-4ac=M^2$. Irrational (conjugate) if $b^2-4ac\neq M^2$. May be entire or mixed surds if $b=0$.

(2) Real and equal if $b^2-4ac=0$. Roots are rational. Roots integers if numerator a multiple of denominator.

(3) Imaginary if $b^2-4ac<0$. Pure imaginary if $b=0$. Complex if $b\neq 0$. Roots are conjugate.

The graph of $y=ax^2+bx+c$. Let a, b, and c be integers and a always positive. Then there are thirteen different positions of the graph, depending upon the algebraic sign of b and c or whether b and c, either or both, are zero, or whether

$$c \begin{matrix} < \\ = \\ > \end{matrix} \frac{b^2}{4a}$$

These positions are given in Figure 1.

1. If b is $+$, and $c=0$.
2. If b is $-$, and $c=0$.
3. If $b=0$, and c is $+$.
4. If $b=0$, and c is $-$.
5. If $b=0$, and $c=0$.
6. If b is $+$, and c is $-$.
7. If b is $-$, and c is $-$.
8. If b is $+$, c is $+$, and $c<\frac{b^2}{4a}$.
9. If b is $+$, c is $+$, and $c=\frac{b^2}{4a}$.
10. If b is $+$, c is $+$ and $c>\frac{b^2}{4a}$.
11. If b is $-$, c is $+$, and $c<\frac{b^2}{4a}$.
12. If b is $-$, c is $+$, and $c=\frac{b^2}{4a}$.

13. If b is $-$, c is $+$, and $c > \frac{b^2}{4a}$.

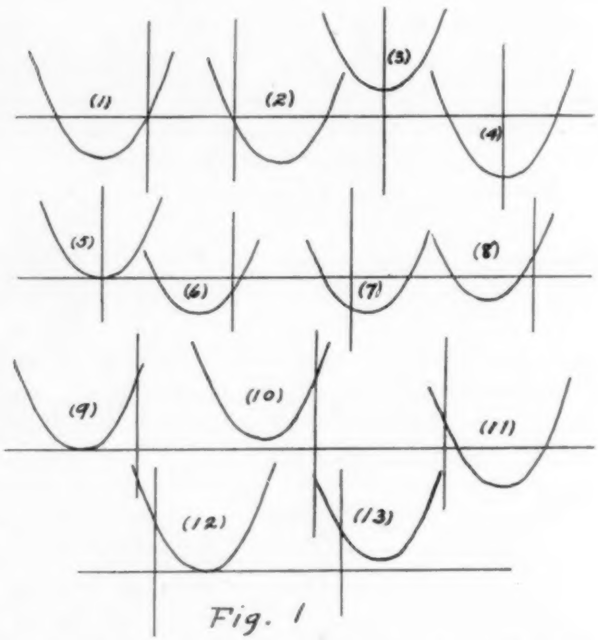

Fig. 1

The graph of the equations previously given illustrate these several positions, viz., 3, 12, 10, 8, 13, 6, 14, 2, 15, 11, 1, 16, and 17. In Figure 1, positions 1, 2, 4, 6, 7, 8 and 11 exhibit the case of *real* and *distinct* roots; positions 5, 9 and 12 exhibit the case of *real* and *equal* roots; while positions 3, 10 and 13 exhibit the case of *imaginary* roots.

Quadratics with a Parameter.

A set of questions will now be applied to each of the following equations.

Questions.

1. What real values of k make the roots real and equal?
2. What real values of k make the roots imaginary?
3. What real values of k make the roots pure imaginary?
4. What real values of k make the roots complex?
5. What real values of k make the roots real and distinct?
6. What real values of k make the roots entire or mixed surds?

For problems in which the radicand in formula (A) is of the first degree, a *seventh* question may be used.

7. What real integral values of k make the roots rational?

Examples.

Example 1. $3x^2-12x+k=0$.

Formula (A) gives $x=\dfrac{6\pm\sqrt{36-3k}}{3}$.

The graph of $y=36-3k$ is shown in Figure 2, from which it is evident that y or $36-3k$ is positive for all values of $k<12$ y is zero at $k=12$, and negative for all values of $k>12$. Hence the answers to the seven questions are as follows:

1. $k=12$.
2. $k>12$.
3. None, since coef. of x can not = zero.
4. The same as for 2.
5. $k<12$.
6. None, see 3.
7. $k=\dfrac{36-M^2}{3}=12-3n^2$ if $M=3n$, in which n may have all integral values.

Example 2. $x^2-2(k-4)x+k^2-12k=0$.

(A) gives $x=k-4\pm\sqrt{4k+16}$.

The graph is easily made.

Answers.

1. $k=-4$.
2. $k<-4$.
3. None, since $k=4$, when $k-4=0$.
4. $k<-4$.
5. $k>-4$.
6. $k=4$, gives $x=\pm4\sqrt{2}$.
7. $k=\dfrac{M^2-16}{4}=n^2-4$ if $M=2n$.

Example 3. $kx^2-2(k-5)x+k-4=0$.

(A) gives $x=\dfrac{k-5\pm\sqrt{25-6k}}{k}$.

The graph is easily made.

Answers.

1. $k=4\frac{1}{6}$.
2. $k>4\frac{1}{6}$.
3. $k=5$ gives $x=\pm\frac{1}{5}\sqrt{-5}$.
4. $k>4\frac{1}{6}$, except $k=5$.
5. $k<4\frac{1}{6}$, except $k=0$.
6. None, since $k=5$, when $k-5=0$.

7. $k = \frac{25-M^2}{6} = 4-6n^2 \mp 2n$ if $M = 6n \pm 1$.

Example 4.

$$9x^2-6x(k^2-19k-20)+[k^4-38k^3+321k^2+763k+364] = 0.$$

(A) gives $x = \frac{k^2-19k-20+\sqrt{36-3k}}{3}$.

The graph of the radicand is easily made.

Answers.

1. $k = 12$.
2. $k>12$.
3. $k = 20$, gives $x = \pm\frac{2}{3}\sqrt{-6}$. The roots of $k^2-19k-20 = 0$ are -1 and 20.
4. $k>12$, except $k = 20$.
5. $k<12$.
6. $k = -1$, gives $x = \pm\frac{1}{3}\sqrt{39}$.
7. $k = \frac{36-M^2}{3} = 12-3n^2$ when $M = 3n$.

Example 5. $x^2+2(k+2)x+9k = 0$.

(A) gives $x = -(k+2)\pm\sqrt{k^2-5k+4}$.

The graph of $y = k^2-5k+4$ is shown in Figure 3.

Answers.

1. $k = 1$ and 4.
2. $1<k<4$.
3. None, since $k = -2$ does not lie between A and B.
4. Same as for 2.
5. $1>k>4$.
6. $k = -2$ gives $x = \pm3\sqrt{2}$.
7. Omit question 7 for the remaining examples.

Example 6.

$$x^2-2(k^2-4k-5)x+(k^2-4k-5)^2-(k^2-9k+14) = 0.$$

(A) gives $x = k^2-4k-5\pm\sqrt{k^2-9k+14}$.

The graph of $y = k^2-9k+4$ is similar to Figure 3.

Answers.

1. $k = 2$ and 7.
2. $2<k<7$.
3. $k = 5$ gives $x = \pm\sqrt{-6}$.
4. $2<k<7$, except $k = 5$.
5. $2>k>7$.
6. $k = -1$ gives $x = \pm2\sqrt{6}$.

Example 7. $x^2-12x+k^2 = 0$.

(A) gives $x = -6\pm\sqrt{36-k^2}$.

See Figure 4 for the graph of $y = 36 - k^2$.

Answers.

1. $k = \pm 6$.
2. $-6 > k > 6$.
3. None.
4. Same as for 2.
5. $-6 < k < 6$.
6. None.

Example 8. $x^2 - 2x + k^2 - 2k + 3 = 0$.

(A) gives $x = 1 \pm \sqrt{-k^2 + 2k - 2}$.

See Figure 5 for graph of $y = -k^2 + 2k - 2$.

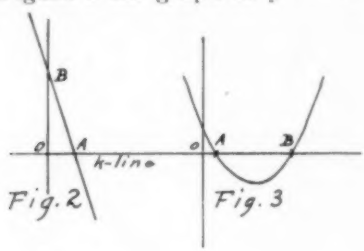

Fig. 2 Fig. 3

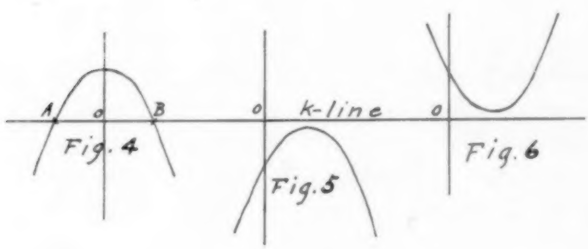

Fig. 4 Fig. 5 Fig. 6

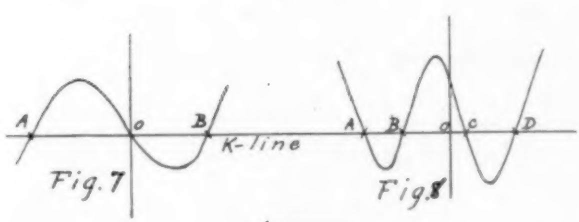

Fig. 7 Fig. 8

Answers.

1. $k = 1 \pm \sqrt{-1}$, not a real value of k.
2. All real values of k.
3. None.
4. Same as for 2.
5. None.
6. None.

Example 9. $(9 + 4k^2)x^2 + 24kx + 36 = 0$.

(A) gives $x = \dfrac{-12k \pm \sqrt{-(36)^2}}{9+4k^2} = \dfrac{-12k \pm 36\sqrt{-1}}{9+4k^2}$.

The graph in this case is a line parallel to the k- line and one unit below it.

Answers.

1. None.
2. All real values of k.
3. $k = 0$, gives $x = \pm 2\sqrt{-1}$.
4. Same as for 2, except $k = 0$.
5. None.
6. None.

Example 10. $x^2 - 2x(2k-5) - 3k^2 + k + 4 = 0$.

(A) gives $x = 2k - 5 \pm \sqrt{7(k^2 - 3k + 3)}$.

See Figure 6 for the graph of $y = k^2 - 3k + 3$.

Answers.

1. $k = \dfrac{3 \pm \sqrt{-3}}{2}$ not a real value of k.
2. None.
3. None.
4. None.
5. All real values of k.
6. None, since $k = 5/2$ gives $x = \pm 7/2$.

Example 11. $x^2 - 2x - (k^3 + 2k^2 - 15k - 1) = 0$.

(A) gives $x = 1 \pm \sqrt{k(k^2 + 2k - 15)}$.

The graph is shown in Figure 7.

Answers.

1. $k = -5$, 0, and 3.
2. $-5 > k$ and also $0 < k < 3$.
3. None.
4. Same as for 2.
5. $-5 < k < 0$ and also $k > 3$.
6. None.

Example 12. $x^2 - 2x - (k^2 - 11k + 28)(k^2 - 5k + 5) + 1 = 0$.

(A) gives $x = 1 \pm \sqrt{(k^2 + 11k + 28)(k^2 - 6k + 5)}$.

The graph is shown in Figure 8.

Answers.

1. $k = -7, -4, 1. 5$.
2. $-7 < k < -4$ and $1 < k < 5$.
3. None.
4. Same as for 2.

5. $-7>k$; $-4<k<1$; and $k>5$.

6. None.

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And many others that might be mentioned.

CLASS ROOM SAYINGS.

State the observations which led to the invention of the barometer.

A.: Galileo was trying to prove to the public that could not be siphoned over 30 and died while he was inventing a device.

Q.: When does a shadow have both umbra and penumbra?

A.: When the light is entirly excrusted by the opaque the umbra is formed; when it is partly excrusted the penumbra is formed (this was from a Chinese boy).

Q.: Why stars invisible at foot of a mountain are visible at the top?

A.: Because the angle is not exact.

NEW PROOF OF THE PYTHAGOREAN THEOREM.

By Herman Katanik,
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Given: Right triangle ABC Δ C, a right angle.

To prove: $\overline{AC}^2+\overline{BC}^2=\overline{AB}^2$.

Proof: Produce BA to S making AS = AB.

Upon BS as a diameter draw a semicircle.

Draw AD perpendicular to SB and equal to AC.

At D erect a perpendicular to AD and extend it to meet the circle at R.

From R drop a perpendicular to SB to meet it at V.

Draw RA.

$$\text{Rt. } \Delta \text{ RDA} = \text{rt. } \Delta \text{ ABC}.$$
$$\therefore \text{RD} = \text{BC}.$$
$$\text{But RD} = \text{VA}.$$
$$\therefore \text{VA} = \text{BC, and RV} = \text{AC}.$$
$$\text{Now VB} = \text{AB}+\text{BC, and VS} = \text{AB}-\text{BC}.$$
$$\therefore \overline{AC}^2 = (AB+BC)\ (AB-BC).$$
$$= \overline{AB}^2-\overline{BC}^2.$$
$$\therefore \overline{AC}^2+\overline{BC}^2=\overline{AB}^2.$$

GRIMSEHL'S LABORATORY.[1]

By N. Henry Black,
Roxbury Latin School, Boston, Mass.

A Sabbatical Year.

For some time it has been the custom among our colleges to give the professors an occasional year's leave of absence on half pay for travel and study. Recently this excellent custom has been occasionally extended to schoolmasters and this paper is one of the fruits of such a sabbatical year which was granted to me in 1912-13. The greater part of the academic year I spent as a student in the University of Berlin, where I had the good fortune to hear every day the inspiring lectures of Professor Rubens on "Experimental Physik."

A German School.

One of the most interesting schools which I visited was the Oberrealschule auf der Uhlenhorst in Hamburg. This school has become famous for its physics instruction, largely due to twenty-five years of prodigious work by Ernst Grimsehl. The school is situated in a residential section of the city and is a school for boys only. It has no Latin nor Greek in its curriculum, but lays great emphasis on the modern languages, mathematics, and science. It provides a nine years' course of instruction, taking the boy from his tenth to his nineteenth year, when he is ready for the university or technical school. In America this training would correspond roughly to the last three years of the elementary school, the four years of high school, and the first two years of the scientific course in college.

From the table showing the course of instruction it will be seen that the German boy has about thirty periods of instruction per week, instead of the sixteen to twenty periods common with us. This is largely possible because the instruction is more generally given orally by the instructor with very little dependence upon the textbook. In this school there are thirty-five regular teachers (all men) and in addition four men devoting a part of their time to the school work. Each man teaches about twenty-one periods per week. The school week consists of six days of six periods per day.

[1]This is a partial report of an illustrated talk given before the Eastern Association of Physics Teachers on Nov. 21, 1913.

COURSE OF INSTRUCTION.

Subjects.	VI.	V.	IV.	IIIb.	IIIa.	IIb.	IIa.	Ib.	Ia.	Total
Religion	2	2	2	2	2	2	2	2	2	18
German	6	5	4	4	3	4	4	4	4	38
French	6	6	6	5	5	5	4	4	4	45
English	..	..	4	4	4	4	4	4	4	28
History	..	..	2	2	2	2	3	3	3	17
Nature-study	2	2	2	2	2	2	.....	.....	.....	12
Computation	5	4	2	1	1	1	.....	.....	.....	14
Mathematics	..	..	2	5	5	5	5	5	5	32
Natural Sciences	2	2	2	2	5	5	7	7	7	39
Drawing	..	2	2	2	2	2	2	2	2	16
Writing	2	2	1	1	..	..	.....	.....	.....	6
Totals	25	25	29	30	31	32	31	31	31	265
Singing	2	2	2	2	1	..	.....	.....	.....	9
Gymnastics	2	2	2	2	2	2	2	2	2	18
Electives[2]:										
Spanish	..	..	..	..	..	..	2	2	2	6
Descriptive Geometry	..	..	..	..	..	..	2	2	2	6
Laboratory Work	..	..	..	..	..	..	2	2	2	6
Totals	29	29	33	34	34	34	33-37	33-37	33-37	310

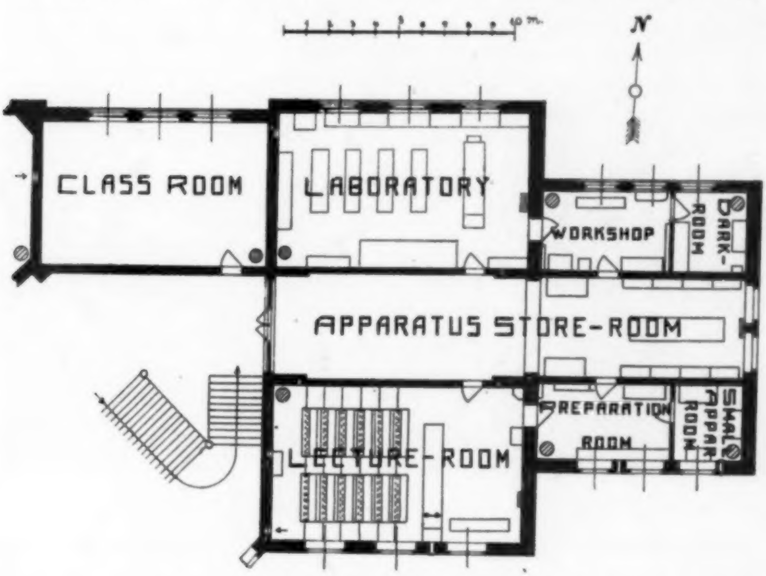


FIG. 1.—ARRANGEMENT OF ROOMS.

PLAN OF THE ROOMS.

The rooms devoted to physics instruction are all on the second floor in one wing of the building, and are quite distinct from the rooms devoted to chemistry and biology. The floor space is about 250 square meters. The rooms are a lecture room, a

[2]Each pupil must take at least four optional periods of instruction. A period is 45 minutes.

preparation room, a big apparatus room, a small apparatus room, a students' laboratory, a workshop, and a dark room.

From the plan given in Figure 1 it will be seen that the rooms are arranged very conveniently. The impression which a visitor gets is that they are clean, well lighted, and have plenty of cases, drawers, and cupboards. One rather striking feature is that the floors are covered with linoleum, which is in turn laid on cork an inch thick, thus making the floors almost noiseless. It should also be noted that the location of the lecture room on the south side of the wing makes the study of the solar spectrum convenient. It is advisable to have all the apparatus rooms placed on the north side of the wing because rubber and especially hard rubber apparatus is injured by sunlight.

FIG. 2. INSTRUCTOR'S WORKSHOP.

The electrical equipment consists of a three-wire system of direct current at a pressure of 220 volts. Each room is supplied with electrical terminals as well as gas and water. We were interested to find that the switchboard is placed in the preparation room rather than in the lecture room, in order to leave the latter free from anything which might distract the attention of the students.

THE SHOP.

The shop (Figure 2) is near the students' laboratory and the apparatus storeroom. In the middle of the room is a small metal

turning lathe driven by an electric motor. On the side toward the windows is a carpenter's bench and a shelf with a machinist's vice. In one corner of the room is a regular German glass-blower's table. In cupboards and drawers and along the wall one finds a good supply of brass and iron, wire, rods and sheets, and in the boxes on the shelves all sorts of screws and binding posts for wood and metal work. Adjoining this room is the room marked "dark room," which is used as a private laboratory by Professor Grimsehl. Here he tests new apparatus and invents apparatus as well as doing small photographic jobs.

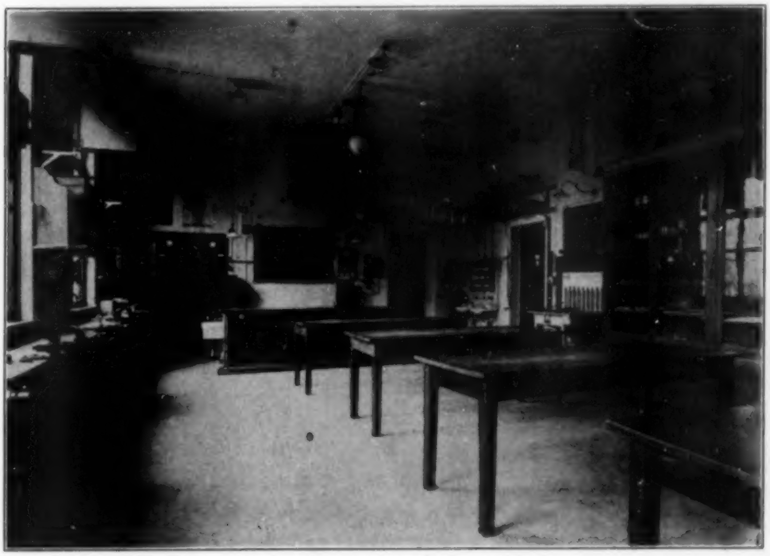


FIG. 3. STUDENTS' LABORATORY.

STUDENTS' LABORATORY.

This room (Fig. 3) is 11 by 6.7 meters and has three north windows. It was designed for only twelve boys, one working at the old lecture table in front, two at each of the other four tables and one in front of each of the windows at the wall table, which is 95m. long, 45cm. wide, and 81cm. high. Ten is considered the desirable maximum number of students. The tables (3m.x90cm.) have oak tops and strong legs. Since they have no sort of conductor to them, they can be moved as seems practical for a special experiment. All the apparatus for the students' experiments is kept in this room, entirely distinct from the lecture room apparatus. Along the wall shelf in front of the windows are connections to gas, water, and electricity. In the rear

of the room is a wall shelf with four balances. There is a storage battery and small switchboard near the teacher's blackboard. The laboratory is supplied with sufficient apparatus of a very simple sort so that the students work with *even front*.

Apparatus Storeroom.

One of the striking features to an American visitor is the large amount of space which is devoted to properly storing lecture-room or classroom demonstration apparatus. In this school we find one large storeroom (20m.x4.4m.) and a small storeroom (3m. x 3.5m.) especially for optical apparatus. There are plenty of cabinets and closets, as well as tables for the care of the apparatus. Much attention has been given to the proper arrangement of the apparatus so that it can be quickly removed and placed on the lecture table. Experience has shown that it is very convenient to keep all the little pieces of apparatus which are used in any experiment together in one box. In this school are more than two hundred such boxes (25x15x6cm.). Each of these boxes is labelled at each end and they are stacked two or three high. It is needless to say that the apparatus itself is of a very high order of workmanship.

Lecture Room.

The lecture room (Figure 4) was designed for forty-eight boys, but for an evening lecture can be made to accommodate seventy or eighty people. We notice at once that this room has no folding tablet arms to the chairs but very substantial wooden fixed benches with a small shelf in front. These strike an American at first as being very hard, but after some experience I am convinced that they are the most practical and serviceable form of seat and desk for a school lecture room. The lecture table is placed about a meter in front of the seats. It is 4m. long, 80cm. wide and 91cm. high. It has a smooth flat top made of oak 4cm. thick. This table top can be lifted off by two strong men and in a space just beneath one finds all the piping and wiring for gas, water, and electricity.

Another noticeable feature about this lecture room is the large space (3m.) behind the lecture table which is designed for especially large pieces of apparatus such as falling body machines, mercury pumps, and dynamo machinery. This large space enables the pupils to gather around the apparatus on all sides. It is also useful for experiments, such as the refraction of light, which can best be conducted only at right angles to the regular

lecture table. Instead of the pneumatic trough which is commonly found in such lecture tables, a sink is placed at one end of the lecture table. On the left side toward the window is a movable shelf 50cm. broad which can be made to connect with a wall shelf, thus making the table 5m. long. In the south wall is placed the opening for a heliostat, at such a height that one can change instantly from sunlight to an electric arc on the lecture table for optical experiments.

FIG. 4. PHYSICS LECTURE ROOM.

In the rear of the room is the projection table and a cabinet for keeping lantern slides and the various lantern attachments. The screen (3m. x 3m.) is at such a height that a horizontal ray from the lantern strikes its middle point. Near the projection table is a socket for the electric connection, a switch for instantly illuminating the room, and gas and water taps. Close by is an opening to a waste pipe. Behind the lecture table, in addition to the sliding blackboards, one finds a voltmeter with various resistances and an ammeter with suitable shunts, and these instruments are wired to the lecture table. Another instrument which is not commonly found in American school lecture rooms is a reflecting galvanometer which is illuminated by a Nernst lamp. The galvanometer scale is hung from the ceiling so that the class can see the spot of light by darkening one window. There are several strong hooks attached to T-beams in the ceiling. Between

the experiment table and the first row of seats, there is a clamp in the ceiling for stretching and twisting experiments. The room can be darkened by heavy light-tight shades, but each one must be operated independently and by hand.

GRIMSEHL'S APPARATUS.

Not less interesting than the laboratory itself is the apparatus. It is the product of a rarely fertile imagination. One finds here many pieces of apparatus which are not commonly described in dealer's catalogues. Among the pieces of apparatus which seemed to me particularly useful and instructive was the toy locomotive mounted on a bicycle wheel as shown in Figure 5. When the

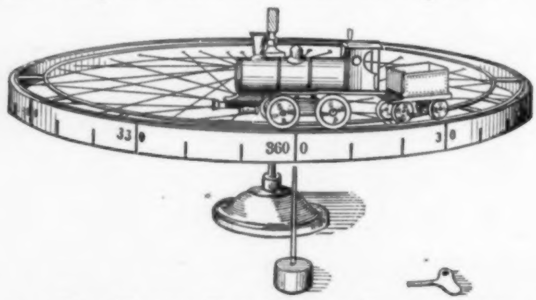


FIG. 5. THE TRACK PUSHES THE ENGINE FORWARD.

student sees this little toy engine pushing its track backward as it goes forward, the meaning of the *interaction of forces* really becomes plain. Another piece was designed to show the side push of a magnetic field on a wire carrying a current as shown in Figure 6. Here the fundamental principle of the motor re-

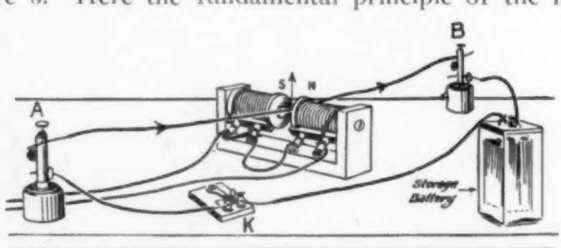


FIG. 6. A WIRE IN A MAGNETIC FIELD.

duced to its simplest terms is made evident to the student at a glance. We have doubtless all been bothered at one time or another to show the *dark line* produced by the absorption of light in sodium vapor, but Professor Grimsehl's apparatus as shown in Figure 7 not only shows the dark line, but can be set up in a reasonably short time. The essential feature of this apparatus is the very wide sodium flame produced by the broad bat's

wing tip on the Bunsen burner which heats the asbestos boards which have been dipped in common salt solution. Another feature which adds much to its convenience is the direct vision spectroscope and handy little arc lamp.

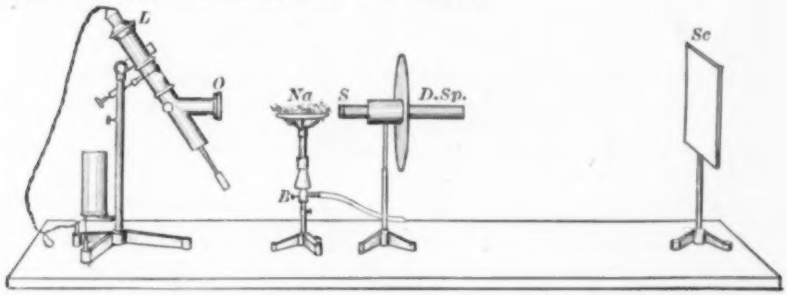


FIG. 7. ABSORPTION OF LIGHT BY SODIUM VAPOR.

This laboratory, as was said in the beginning, is the result of twenty-five years of prodigious work. In Figure 8 we see the worker, Grimsehl, with some of his electrical apparatus in his own lecture room. Professor Grimsehl was warm hearted, a

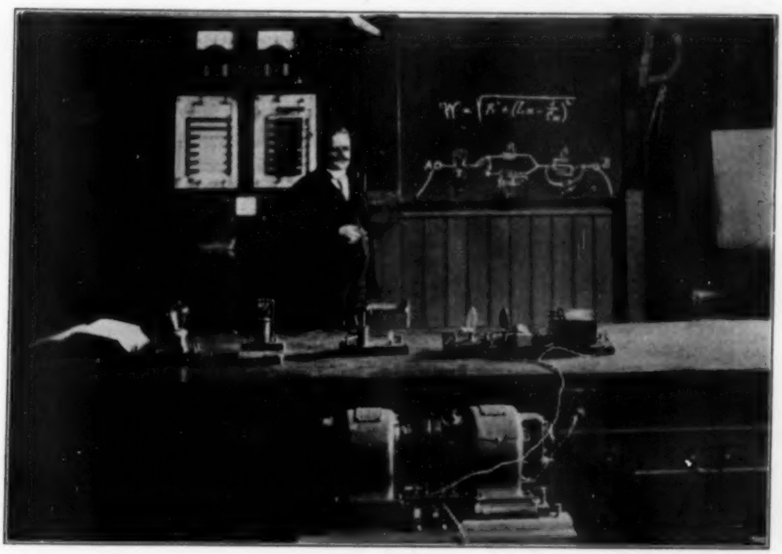


FIG. 8. GRIMSEHL, THE TEACHER.

tremendous worker, an enthusiastic teacher, a clever inventor, a lucid writer, and an efficient executive. It is with the deepest regret that I have recently learned that he met his death October 30, 1914, fighting for his country. Not only Germany but the whole world has lost a most powerful influence for the improvement of physics instruction.

SOME THINGS TEACHERS SHOULD KNOW ABOUT THE WORK OF OTHER TEACHERS.

If an instructor in any particular line of work does not have breadth and depth of mind enough to keep himself posted and in touch with matters that are being carried out by others who are doing the same kind of work that he is attempting to carry out, he will invariably go to seed. In order to fully keep in touch with advanced work, provision should be made by every Board of Education to permit its teachers to visit schools not only in their immediate vicinity, but in other cities, in order that they may secure new ideas and perhaps get rid of some old ones. In doing this the teacher will necessarily become very much more efficient, because he will become enthusiastic over the work being done outside, and he will also be made to believe that his Board means to treat him fairly.

This leads to the suggestion, which has been carried out in some localities, that schools can be improved as far as the quality of the work is concerned, by frequent exchange of teachers for a month or more. This not only is helpful to the teachers, but it reacts directly on the pupils as a whole, in bringing into their school life ideas, suggestions and personalities from other educational centers. Progressive teachers should work and push for something of this kind to be worked out in the schools with which they are connected.

THERMOMETERS IN DISTILLATION FLASKS.

Complex mixtures of hydrocarbons of different chemical composition are separated into simpler fractions by fractional distillations carried out between definite temperature limits. Such distillations are carried out in laboratory tests in several different forms of flasks, in which the temperature limits fixed by the specifications are measured by mercurial thermometers, the stems of which project out of the flask into the room, and thus cause the thermometers to read too low, i. e., lower than they would read if the bulb and stem were all at the temperature of the oil vapor around the bulb. To find the true temperature of the vapor, it is therefore necessary to apply a so-called stem correction to the observed reading of the thermometer. In the paper above referred to, these stem corrections have been determined for several different forms of distillation flasks and it is shown that in oil distillations, tests carried out in the interval, 200° to 300°C., it may amount to over 15°C. (27°F.), and it is shown that different chemists fractionating the same oil will find quite different results if one applies the stem correction and another neglects to do so.

The paper also gives a very simple method by which the chemist can determine the total correction that he must apply to the observed reading of his thermometer to find the true temperature of the vapor in the flask, i. e., the total correction due to scale error and to emergent stem. The method consists in reading the thermometer when naphthalene is boiled in the flask and again when anthracene is boiled in the flask. The boiling point of the former has been found to be 218°C. and of the latter 340°C. The amount by which the observed thermometer readings differ from these two temperatures gives the total correction to the thermometer at two points on its scale, and corrections at intermediate points can be found by interpolation.

Copies of this paper may be obtained without charge upon application to the Bureau of Standards, Washington, D. C.

IS THERE A "ROYAL ROAD TO SCIENCE"?

By Hanor A. Webb,
West Tennessee State Normal, Memphis, Tenn.

Chemistry was formerly a sort of "parlor entertainment" subject. In the average high school, the lecture method was of necessity in vogue—the teacher discussed selected passages from "sixteen weeks"—the student received a few easy credits. The subject was popular, of course.

The equipment of laboratories—the introduction of quantitative experiments—the employment of teachers more thoroughly trained, and hence able to offer more subject matter in a given course—these, and other circumstances have raised chemistry from a lightweight subject to one of first rank. Statistics, however, from the Department of Education (see chart, page 221, March number of School Science and Mathematics) show that the percentage of high school pupils taking this, and other laboratory sciences, has slowly decreased.

To many science teachers, this fact seems discouraging—to others, it appears as a logical result. For example, in this section of the South, there are schools which formerly gave courses in chemistry without a laboratory, but have now wholly abandoned them. Laboratory equipment is now considered necessary, and this they could not afford. A comparison of old textbooks with those widely used at the present time will show that the subject of chemistry is weightier, yet more practical than ever. And many teachers take comfort in the thought that the loss of students has been merely the elimination of some of the unfit.

But there is another reason offered in a recent number of School Science and Mathematics.[1] In this article (from which I often quote) there is a strong protest against requiring the student to earnestly apply himself to the mastery of the "fundamental" laws of science, and the intimation is made, that in certain new methods, in which these "fundamentals" are but little emphasized, a cure for the causes which have resulted in the decrease of science students will be found.

I would not attempt to uphold, in their entirety, the older methods of teaching these fundamentals, which were, perhaps, analogous to the plan of teaching grammar without illustrating sentences. But our most modern, "practical" advisers have

[1] "Science Teaching by Projects," John F. Woodhull, page 225, March Number, School Science and Mathematics.

turned the old, white-haired, and venerable "fundamentals" out of the scientific congregation. In two of our newest textbooks, their names cannot be found in their accustomed place in the "list of members" (index), and they are barely mentioned, as having once-upon-a-time belonged. Perhaps their voices did not harmonize perfectly when the "live-and-up-to-date choir" sang. They were not sufficiently "progressive"—but you can't expect an old deacon to approve of moving pictures in the church.

I admit with all candor that processes of science can be taught without reference to the fundamental principles—we have the method of the "Rule of Thumb." Unfortunately, such methods are the foundations of many of the "applications" of physical and chemical processes in our manufacturing plants. The average manufacturer, and the young "commercial chemist" just graduated from the strictly "trade high school" are inclined to make light of the theory of the various processes with which each presumes himself to be familiar.

The "Rule of Thumb" fails in an emergency. In his *Chemistry of Commerce*, page 116, Duncan tells us of a glass manufacturer who wasted hundreds of dollars worth of raw material —days of time—and lost a thousand dollars in orders for ruby glass, because cupric oxide was being used in his recently purchased formula, instead of the specified cuprous oxide. In my own experience, a young "combustion expert," employed by the local street railway, found that his carbon monoxide readings were not in agreement. He had just bought a new supply of "copper chloride" from a local wholesale druggist. Yes, it had looked a little off color, but the druggist swore that it was copper chloride. A few questions showed that the young man did not clearly understand the "fundamental" difference between "ous" and "ic."

On the other hand, the "Rule of Thumb" student is often timid, and is at a loss if the definitely specified things are not at hand. In the preparation of hydrogen, most manuals suggest that a little copper sulphate be added to the zinc and acid. At this time, I always empty the copper sulphate bottle, and leave it standing beside the copper acetate. And what student, who is only as far as hydrogen (according to the "old" system, of course—in the newest book, they are studying the hydrolysis of starch into erythrodextrose, achroodextrose, iso-maltose, etc., by this time)—I repeat, what student, who is only as far as hydrogen, can keep from being frightened at that fearful radical, $C_2H_3O_2$! But I

have endeavored to give a little "fundamental" instruction in catalysis, and in the principle of a couple, and the trick rarely works.

Thus, in the "Rule of Thumb" method, one never knows when something else is just as good, or when it isn't!

Why do we hear so much opposition to those things in science which are not of immediate practical value? The average man has less use for algebra and geometry than for any other subject —that is, he makes less immediate use of them in his daily life. To say nothing of the women, the housekeepers of the Nation! To thoroughly uphold the ultra modern views of science, we must be in complete accord with a recent speaker at a meeting of nation-wide interest, who said he "gloried in the spunk of a girl who absolutely refused to study algebra!" If we limit ourselves to the purely "practical," what shall we study and teach? We spell words in school which we never see again—learn names, dates, and even movements in history which we promptly forget —study about countries which we never hope to see, and so on, ad infinitum! And the worst of it is, that this demand for the "practical" in science spreads to those in authority, those who have the power to formulate courses of study—outline syllabi— or require certain visible results—men skilled in literature, history, business, and even politics—but not in science!

For example, the Superintendent of Schools in one of our largest Southern cities said to his chemistry teacher, who had a class of ninth grade boys starting in "vocational work," "Make practical chemists out of these boys, sir! When the term is over, we will send them out to every well in the city, and each boy shall analyse the water from these wells. We will show these people what we teach here!"

We cannot expect *every* fact we teach to have a visible and immediate relation to life. It may be an evil, but it seems to be a necessary one, that the student must early learn some *terms*, that the language of science may be intelligent to him. Some *rules* must be formulated for him in thoroughly scientific language— some things must be learned by heart. A few topics seem to require a certain amount of old fashioned drill, for I have conscientiously tried to teach them successfully without it. There is nothing to commend in the old method of *unillustrated definitions* —but it was no more difficult to the student than a mass of *undefined illustrations*. These two methods of presentation are certainly characteristic of the obsolete and ultra modern texts,

respectively. Are not a set of general laws, even if poorly illustrated, as likely to stick in the memory as a mass of isolated facts?

I am sure that the great body of the science teachers of our Nation will have little patience with those who hold the "fundamentals" up to ridicule. Well balanced people recognize the necessity of a foundation for every structure. We must first build our wall before we spread our "practical" paint upon it. Try to lay a "practical" floor without "fundamental" joists beneath it. I admit, too, that the paint and the floor have a more apparent relation to daily life.

"Archimedes, Galileo, Davy, Faraday, Pasteur, Tyndall, and all the rest" did not deal with the purely "practical" things of their day. They went far deeper than the superficial. No scientist has ever founded a reputation upon a hodgepodge of "practical" facts—it requires the discovery of some fundamental principle to carry his name down through the ages.

"But the practical is in greater demand!" we hear. The "vox-populi" were ever words to conjure with. Teachers know, however, that the demands of parents are usually based upon reports of students. "But the students are far more interested!" Certainly, to a student, a "practical" experiment will be very interesting—for the first time or two. It turns a pretty red—my-y-y-y-y!—it flashes with a big flame—wh-e-e-e-e-e! and that's about all there is to it. Or if it is in physics, the fork goes pin-n-n-n-ng, or the little bell rings, and a "practical experiment" is done.

The very popularity of a course may indicate its tendency to soft and easy methods. It is hard to tell the difference between "interest" and "excitement" in a pupil. What things are the most interesting, and the most enjoyed by the typical high school boy and girl today? Extremes of dress—secret societies—the tango—and all other forms of ultra modernism. Sweets were ever seductive, and if constantly indulged in, the taste for more substantial food is lost. Too many of our "practical" lessons in the latest science texts are not like a square meal—they are each a dose of stimulating dope! We may expect an apparent increase of interest—students always loudly shout when entering upon what appears to be the "Royal Road to Science!"

Let us not discriminate between the subjects in our high school courses! I am for fair play to the student! If Boyle's and Charles' laws are to be eliminated from our chemistry texts, I demand that type formulæ be removed from the pages of factor-

ing. They are both too "fundamental." "Let the pupil walk alone, by attacking real problems," we are advised. If we no longer need the index of refraction to do intelligent "practical" experiments with lenses, let us do away with the Second Declension! How our "unerring instincts did revolt" at that—how we were "pleading to get rid of our teachers" that we might avoid it—that we might sooner learn the "practical" lessons of how Cæsar built the bridge!

At least two of the modern high school texts on chemistry I regard as parasites, having no roots grounded in fundamental principles, from which nourishment may be drawn, but dependent for their usefulness upon the additional knowledge which the teacher possesses, and his ingenuity in explaining the many bald, bare statements of fact which occur in the pages of the book. With most texts, an inexperienced teacher would make a fair success, with these, he would utterly fail. An ambitious boy, working independently in his own laboratory, would find the books so superficial as to be of no service to him.

In some quarters, it is claimed that the demand for General Science is a revolt against the present methods of teaching physics, chemistry, and the other recognized branches of high school science. My impression of its proper spirit is to bring the first instruction in elementary science from the third to the first year of high school, closer to the age of adolescence—so that the wonderful powers of reason—new born, as the psychologists tell us, like the little chick, which, although alive, has been encased—may seize upon these morsels of scientific knowledge which reason craves—the immediate, surging questions be answered, and a strong taste for the study of science be created. General science, I have thought, would be a forerunner of the systematic study of science—making the way straight, the road smooth. But there are those who insist that General Science should supplant! Shall we weed and fertilize our garden to make it bear in more abundance, or shall we uproot what is there!

General Science is, at present, an attractive looking infant, and will, no doubt, grow into robust manhood. But from the descriptions which are written of him by his fond nurses, he is in danger of precociousness. If he can do all at present which is claimed for him, he may be discussing the "fourth dimension" at the age of nine. True, there is a "fundamental" principle connected with the fourth dimension, which is rather difficult, but that could easily be dispensed with in the interest of the "practical" applications.

It is largely the custom, in hotels, to serve the dinner in courses. You have to finish your soup, before you get any meat. You must eat the salad, before you may sip the cafe noir. In the hotels of small towns of this section, however, the cook sends in a little of each preparation on a small dish, and all are spread before you. Science, previously served in courses, with much success, may some day be served in little portions all at once, if the advocates of General Science are not conservative. It may be modern, but there should be some patient and conclusive research on digestion in each instance.

Between the two extremes, there is always a happy medium. It is quite true that much chemistry and physics has been taught in a rather lifeless manner in the past. But on the other hand, neither will superficial knowledge make a nation of people who appreciate what science is doing for them. My belief, and practice is, to give as substantial a course in high school chemistry as possible, enlivened with as many practical applications of the fundamentals as time will permit, but not to the exclusion of a certain amount of that drill which the Latin, mathematics, and even the botany teacher find absolutely necessary in their work. I believe the gas laws, Avogadro's hypothesis, the ionic theory, and some knowledge of mass action are to be included in these "fundamentals," but I have my own private opinion (which I would not urge on any one) as to where these should be introduced in the course. After this general inorganic course, I let down the bars, and next year we have applied chemistry to our heart's content. And these classes, working with foods, textiles, medicines, the soil, and many other things, are truly a source of inspiration. I believe the knowledge gained is solid, having a firm foundation. I might say also, that I teach a class in elementary applied chemistry to pupils who have no previous knowledge of the subject. My beliefs come from experience with a "condition, not a theory."

We must not be surprised that in this movement, there are zealous enthusiasts who advise types of teaching which bear all the earmarks of a fad. They are disciples possessed of a "zeal not according to knowledge." It is typical of all awakenings. But we must recognize that some of these plans cater to the instinctive demand of the beginner for some "fireworks"—that same demand of the unscientific public which causes the erection of cheap buildings, attractive, seemingly practical, on the outside, but internally, "fundamentally" only temporary structures.

After a series of attempts to pass along the "Royal Road to Chemistry," the student will have one of two attitudes toward the subject—either he will look upon chemistry as cheap, because it was so easy, and, surfeited with its sweets, seek for no more substantial portion—or, realizing that only a "prospectus" has been offered him, accuse the teacher for wasting his time, and demand that the real book be given him. If we, as teachers, have scientific knowledge to dispense, let us not be content with merely handling free samples—let us offer the real article—full weight—full measure!

A STUDY OF SCIENCE INSTRUCTION IN MISSOURI HIGH SCHOOLS WITH SPECIAL REFERENCE TO GENERAL SCIENCE.

The committee, appointed to make a study of science instruction in Missouri high schools and to determine, if possible, what a course in general science has to offer in betterment of present conditions, has found its problem a large and difficult one. In order to thoroughly understand the status of the existing courses in the high school, the chairman of this committee has made an extensive study of the enrollments in all of the first class high schools in this state from 1905 to 1913 inclusive. In this study we have determined, not only the total enrollment, but also the enrollment by subjects for the entire period, compiling our data from the reports of the State Superintendent of Public Schools. In 1905 there were 61 first class high schools in Missouri. In 1913 there were 151 such schools. The value of science teaching equipment in the schools under study was $53,141 or $871.15 per school. In 1913, this figure had increased to $240,242, or $1,591 per school. In 1905 these schools had $5.00 per pupil enrolled in science classes invested in science teaching equipment. In 1913 this figure had increased to $15.75 per pupil. We find that, in 1905, 64.4 per cent of all pupils enrolled in high schools were studying science. In 1913, we find that 49.2 per cent of the high school pupils were studying science. This number would be increased to 62.5 per cent if domestic science, as it is taught in high schools, be considered a science. This means that science has lost 15.2 per cent in its percentage enrollment in nine years. It is beyond the function of this present paper to enter into a discussion of the various courses in the curriculum outside the field of science, but we wish to present the facts relating to these

other courses at this time as a background for our further consideration of the subject in hand. The more we study these facts the more evident it becomes that science, as it is being taught in our high schools, is failing to meet public demands, and is slowly being eliminated from the curriculum. It is highly proper for us science teachers, ourselves, to discover these facts, and to turn the searchlight of investigation upon ourselves and our work in an effort to ascertain our duty in regard to the situation.

The tendency of the day is to reduce every subject as nearly as possible to an industrial basis. Those subjects which have not been able to lend themselves readily to this change have suffered a decrease in their enrollments. Some subjects are meeting this tendency by rationalizing their subject matter and the method of presentation. Science has done practically nothing to adapt itself to the changed conditions. Individual teachers in this and other states have done some good work along this line, but we have made no organized effort. During the last nine years, in the first class high schools of Missouri, Mathematics lost only 4.6 per cent in its percentage enrollment. English lost only 1.6 per cent. Latin lost 10.8 per cent. Manual Training lost 7.6 per cent. Drawing lost 5.5 per cent. During this time music gained 3.6 per cent. Commercial subjects gained 11.6 per cent. German gained .6 per cent. Domestic Science gained 4 per cent. Of all the generally recognized high school sciences Agriculture alone shows any gain in its percentage enrollment, while the following losses are noted: Physics 5.6 per cent, Chemistry 1.0 per cent; Zoölogy 8.5 per cent, Botany 9.6 per cent, Physical Geography 3.0 per cent. These losses in percentage enrollment should be a matter of concern to all of us.

Under the plan of tabulation herein used, a subject showing no gain and no loss in its percentage enrollment, has enjoyed an actual numerical gain in enrollment in proportion to the increasing enrollment in the high school. It is to be expected that, with the increasing number of elective subjects in the curriculum, there would come a corresponding decrease in enrollment in the several courses. In spite of this fact, the loss which science has sustained in its enrollment in this state in nine years should be enough to cause educators in Missouri genuine concern.

With such data before us, we are impelled to ask ourselves the question: What is the matter with science in the high school? Has it lost its attractiveness for young people? Are our teachers becoming more inefficient? Is there something wrong with the

science course as we have planned it? These are the questions that should be uppermost in the mind of every one who has to do with the teaching of science in the secondary school.

When science was first introduced into the curriculum it was in the form of a single course—natural philosophy. In this course the class was expected to take up a study of any phenomenon of nature that seemed to them worth while and, although not calling it by any of the names of the specialized sciences as we know them today, they learned the fundamentals of physics, chemistry, biology, physiography, and astronomy. That was at a time when well equipped high school laboratories were rare, and when college trained teachers were equally as rare, and yet we have the testimonials of those of the older generation who were fortunate enough to have come under such instruction, that natural philosophy was a course that was eminently worth while. From this one course our modern specialized high school sciences have been differentiated.

That each of the specialized sciences has merit is universally acknowledged. That each one has done much good no one can doubt. It is, however, becoming increasingly difficult to justify the existence of six or eight separate specialized sciences in the high school curriculum. If it were a wise plan in the long run, the fact that it is neither economical nor efficient to maintain these sciences as we have them today would not concern us seriously. As a matter of fact the average high school pupil will elect only one unit of science. This one course, as we have it today, gives him an extremely narrow outlook upon the world about him, and a very inadequate basis for future scientific study. There is very often not only no apparent connection between the various sciences in the high school, but also no tangible connection between the science the pupil studies and the world in which he lives. He studies science for science's sake, or else for the sake of the credit. It is not surprising that the pupils are increasingly slow to elect science. If we would only look at the question from the pupils' point of view we would not be slow to recognize the need for some radical changes in the general plan of secondary school science. The fact that this question has been under serious consideration for a year before the Central Association of Science and Mathematics Teachers, The High School Conference of the University of Illinois, as well as the Missouri Society of Teachers of Science and Mathematics must be sufficient to convince any one that there is real need for reformation. The fact is

very significant that we are all looking to more or less unification of the sciences as a solution of the problem.

It is not our purpose to condemn specialization of the sciences broadly. The fact, however, that we have over-specialized our high school sciences is becoming more and more evident to almost every one. It is apparent to any one conversant with existing conditions, that we are inevitably coming to a unification of our secondary school sciences. Many teachers plan their science courses to meet college entrance requirements. Those who are thoroughly awake to the situation realize that the general public is at last aroused to the fact that they have a right to demand practicable, usable education for the great majority, rather than special training for the very few who may desire to enter college. Science will either have to fall in with the onward march of progress, or else fall out. There is no longer any demand for science for science's sake in the curriculum of the secondary school.

Our science teachers are of such character and training that they may be expected to adapt themselves to a new plan very readily when once they understand the plan and the need for it. Last year there were more than 200 teachers having ninety semester hours or more above a fifteen unit high school course, graduated from the Normal Schools and the School of Education of Missouri. Of all their college credits, 18.2 per cent is science. Taking that as a typical class, it seems that the preparation of our teachers is all that could be expected, and that the teachers of this generation are not to be counted as inefficient. It must be evident, however, that some of our teachers of science in high schools are slow to realize that high school science can not properly be a miniature of the college course which they as students pursued five, ten or fifteen years ago.

Agriculture is a popular first year high school science. The very close relation of agriculture to all the other sciences is such that the need of a general introduction to agriculture is as real as to chemistry or physics if not more so. Agriculture is so deeply rooted in the formal sciences that its progress is handicapped at every step without some knowledge of the fundamentals of the underlying sciences. To use agriculture as an introductory science helps the more formal sciences but little, and places agriculture under tremendous disadvantage.

Mr. Eikenberry, of the University of Chicago High School, calls attention to the fact that "The desirability of a scientific in-

troduction to agriculture is nowhere more clearly recognized than in some of our more recent textbooks. For instance a high school textbook in agriculture issued in 1913 has its first chapter of 60 pages devoted to chemistry, and the third chapter, 63 pages, is wholly botanical. In neither chapter is there any considerable amount of applied material. Thus there are, in the first part of the book, of 400 pages, more than 120 pages which would ordinarily rate as formal science; must be interpreted as strictly preparatory to the body of the text. This book is not alone in its recognition of the need of preliminary science training." A well planned course in general science, based upon a proper balance of laboratory work, must be THE COURSE to fill this need, and to help save the sciences in the high school.

Some fear it would be difficult to find teachers whose training is sufficiently broad to enable them to teach the elements of so many sciences in one course. As to this Mr. Eikenberry says: "In the course of an investigation into conditions existing in the first year science in Illinois high schools certain data bearing on this point were received from about 200 schools. It appears that in this representative group of schools 69 per cent of the teachers of the first year science were, in 1911-12, handling at least four other subjects; 40 per cent were handling at least five other subjects; and 26 per cent were handling five or more subjects. It is perfectly obvious that under present conditions and, quite aside from fitness or desirability, the teachers of this state are instructing in a range of subjects comparable in breadth with the range of material in proposed general science courses." Doubtless similar conditions exist in Missouri. There is no reason why the average teacher of high school science should not be expected to have the breadth of training to enable him to teach such a course creditably.

Superintendent William H. Smiley, of Denver, said: "I believe the time will come when we shall have a year of general science that will include right information for proper living, in other words, biology that is necessary to understand the hygiene of the home and the city. This can not be taught without some knowledge of chemistry and physics, but there is a place for this kind of work in the high school for all students. It ought to be as common to give this course as it is to give instruction in civics, as a social science."

Any course in general science must follow a definite plan that has been thoroughly organized. It is not sufficient to merely

make a list of studies from which the teacher may select that which seems best suited to given conditions. Many teachers are unable to make such a selection. The studies should take up those phenomena with which the pupil is familiar and in which he has an interest—in the burning of a candle, the glow of a sunset, or a rainbow, and, going from the known to the unknown, work out the scientific principles involved in such a way that the pupil goes away feeling that his science has really made itself indispensable to him.

The above is a copy of a report presented by the undersigned committee to the Missouri Society of Teachers of Mathematics and Science at St. Joseph, Mo., November 12, 1914.

E. B. Street, High School, Mexico, Mo.
A. C. Magill, Normal School, Cape Girardeau, Mo.
R. B. Finley, Consolidated School, Hickman Mills, Mo.
A. R. Miller, St. Louis, Mo.
W. J. Bray, Normal School, Kirksville, Mo., *Chairman.*

Note.—At the meeting above mentioned the Society to which this report was presented practically unanimously endorsed the report of the committee, and passed a resolution to the effect that this Society favor a course in general science as a first year high school science, and that the influence of the Society be used to secure recognition of general science on a par with any other first or second year high school science in this state.

DIRECT-READING DEVICE FOR COMPUTING CHARACTERISTICS OF VACUUM TUNGSTEN LAMPS.

It is well known that a change in the voltage applied to the terminals of an incandescent lamp changes the candle power, current, and, in consequence, the wattage (watts = volts×amperes) and the watts per candle If these changes are followed from point to point, relations among the variables may be found and plotted as characteristic curves. The equations of these characteristic curves for tungsten lamps have been found by the Bureau of Standards, Department of Commerce, and a special application of these equations has been made in a device which gives a solution of problems involving voltage, candle power, and watts per candle.

In this device the volt scale is movable, and, by setting it to the other scales at a point corresponding to the observed watts per candle, values of per cent candle power and of actual watts per candle may be read directly from the proper scales, or the converse problems may be solved. Use of this device results in a decided saving of time when compared with other methods of characteristic evaluation. In connection with the device are given tables of values used in its construction and practical examples illustrating scale settings.

The report upon this subject, just issued, has been designated *Scientific Paper, No. 253,* and copies may be obtained without charge upon application to the Bureau of Standards, Washington, D. C.

HOW I MAKE LABORATORY WORK IN PHYSIOGRAPHY CONCRETE.[1]

By Lewis Walker,
High School, Mahomet, Ill.

A globe and a few wall maps make up the entire laboratory equipment provided by the school. The course was taught during four months' time to a class composed of Juniors and Seniors. The problem of teaching Physiography, making it interesting and concrete, with no apparatus, was one which afforded a great deal of difficulty.

Outline maps were used extensively throughout the work. Each pupil was required to buy a set, which was selected by the teacher. Pupils reproduced on outline maps of North America and Europe, the maps in the book, showing the glacier. Arrows were drawn in the directions in which the glacier extended, fixing in a helpful way its extent and direction. In this way the glacial centers were made plain and pupils saw more readily the extensive effects of glaciation.

Ocean Currents and Atmospheric Circulation were studied in very close relationship one to the other and in detail. The pamphlet, "Circulation of the Atmosphere," prepared by D. C. Ridgley, was in the hands of the teacher and was used as a supplement to the text.

A few facts concerning the air were first mastered, viz., wind is air in motion, air has weight, air when warmed expands, when cool contracts, warm air is lighter than cold air, warm air can hold more water vapor than cold air, moist air is lighter than dry air.

After these facts and examples proving them were thoroughly studied the pupils were ready for a complete study of the circulation of the atmosphere and its relation to man.

Charts were made showing by means of flying arrows the direction in which the air was moving. An imaginary steam pipe was located in the center of the room representing the equator and doldrum wind belt. The air (trade winds) moving in from either side of the room toward the steam pipe (doldrum belt) was warmed, expanded, moved upward toward the ceiling where it divided, some of it passing to either side of the room along the ceiling. This air represented the *anti-trade* winds. When this

[1]Read at the High School Conference, at the University of Illinois, November 20, 1914.

air pressed against the walls it moved downward towards the outer aisles on each side of the room, representing the *horse latitude* wind belts. Here we supposed the air to separate, some of it passing out of the building to represent the Westerlies, and some of it passing back towards the steam pipe as trade winds.

We applied this illustration to the earth without considering rotation. We then applied the illustration to a rotating earth. The pupils applied these facts and mastered the Circulation of the Atmosphere in a very short time.

The fact that pupils who are now in school can reproduce the illustration after one year and apply it to the globe is ample proof that this means of presentation is concrete.

Wind belts maps were drawn showing their average position and their January and July position.

The four questions which determine the rainfall of the earth followed the study of the atmosphere and were applied to the vegetation of the earth and the population. The circulation of water was presented and compared to the circulation of the atmosphere. This was not difficult since the Atmospheric Circulation was studied in such detail. A map showing ocean currents was produced.

A tellurian was improvised by means of a board and pieces of chalk. The chalk was placed in the positions of the earth at the beginning of the different seasons. The earth's orbit was represented by a chalk mark. The globe at hand was so constructed that it illustrated, fairly well, the different positions of the earth. It thus became easy for the pupils to understand why the earth can be nearer the sun on September 21 and March 21 than on June 21 and December 21 and yet not have hot weather nor cold weather.

Perihelion and Aphelion were each brought out and illustrated, as well as could be, at this point. Jackson's Astronomical Geography was used as a supplement to the text in teaching this subject, which so often proves a failure with a class composed of high school children. Nickol's Tellurian is a cheap but effective instrument for the teaching of seasons.

Maps showing land elevation in color were studied. A good atlas in the hands of the teacher was passed around to the class that they might be able to interpret land elevation by contour lines as well as by coloring. A contour map of the local community, if such has been published should be used whenever possible. So far as I know, our immediate region has not yet been shown on a

topographic map. Illustrations drawn by the teacher were placed upon the blackboard for the pupils to interpret.

Salt and flour maps were made to show the physical features of different continents. These maps did not prove so helpful to the pupils as the ones in the book. The pupils looked upon the idea of preparing them as laborious and when the time came to discuss the maps, the individual interest was not so keen as when the maps with contour lines were discussed.

A sun stick owned by the teacher was used to determine the altitude and direction of the sun in degrees and the length, in inches, of the sun's shadow. The sun stick is made of a pine board $8\frac{1}{2}''$x$6''$ with a $3''$x$\frac{1}{4}''$ peg placed in an upright position in a corner at the end of the board. A nail is driven into the board at the diagonal corner from the three inch upright. To this nail is attached a string which has a small weight at the loose end. A quadrant is drawn, using the nail as the center, and is marked off in degrees.

By placing the board in a flat position so that the three inch piece makes a shadow hourly observations were taken. This showed strikingly the change in the direction of the sun and its altitude hour by hour. Thus the earth's rotation was made concrete.

To make measurements of the altitude and direction of the sun the quadrant was used. By placing the board on edge so that the shadow of the nail fell across the quadrant, the altitude was determined with a fair degree of accuracy.

To find the direction of the sun we placed the board square with the world and noted the number of degrees through which the shadow of the nail passed. This gave the pupils a clearer idea of directions.

We next studied the weather. We wrote to the Weather Bureau at Peoria asking for a daily weather map but were refused the request. However, they were kind enough to send us a number of clippings from the Peoria papers containing weather maps, which are published daily. With these we studied, so far as time permitted, the isotherms, and followed highs and lows on successive maps. Pupils noted the barometric pressure in the daily papers and compared the pressure of one day with another and the weather of one day with the weather of another.

This work was very enjoyable and was taken up with much interest, pupils discussing the weather and making comparisons.

We did not learn until later that a daily weather map could be procured from Springfield.

With no instruments at hand except a thermometer, no special weather study could be made by instrumental observations. However, much is possible without instruments.

After looking over the sheet which was purchased as a part of the set of Outline Maps we thought it would prove interesting and profitable to add a few more requisites to the sheet, as it was evidently designed for work in the first eight grades.

On this sheet the date, hour, temperature in degrees, direction of wind, velocity of wind, condition of roads and sky, precipitation, kind and amount of clouds, if any, were given.

This data was tabulated daily from November 10 until December 10, leaving out Saturdays and Sundays and holidays. The time of taking the observations was usually, though not necessarily, about the same each day.

This work was done independent of class although often a discussion of the day's observation was had in class to aid as a guide and a stimulus.

Salisbury's Physiography was used as a supplement to the text in determining the kinds of clouds. Excellent pictures of clouds are to be found in this book, and the pupils found little trouble in determining the kind of clouds in the sky after studying carefully the pictures and what Professor Salisbury says on the subject.

The teacher kept an observation sheet also with which the records of the pupils were compared.

After the work was completed a curve was drawn to show the rise and fall of temperature for the month beginning November 10, and ending December 10. A dash was used to represent a day lost. The curve was drawn on co-ordinate paper.

These are the few methods we used in our school to make the laboratory work concrete.

Each method spoken of in this paper tended to make the Physiography work more realistic in the minds of the pupils besides doing away with memorizing words of the text which had no meaning to many.

The materials are inexpensive, they served their purpose for us and served it well. No doubt they will for you—try them.

A LABORATORY REVIEW.

By H. Clyde Krenerick,
North Division High School, Milwaukee, Wis.

We are probably all agreed that more efficient work can be done in the laboratory when duplicate sets of apparatus are supplied so that all students are working at the same experiement. However, there are many very desirable experiments where the cost of the apparatus is such as to prohibit any duplication. To overcome this disadvantage, I have for two years resorted to the following scheme—a scheme which has not only given me a great amount of pleasure and satisfaction but has been of the greatest interest and attraction to the boys and girls.

The regular year's work of the subject is completed some six or seven weeks before the close of the year. The apparatus for the following twenty-two experiments is then put out. The discussion in classroom of these experiments and related matter constitutes a good review of the year's work. It will be observed that the purpose of these experiments is not to verify the principles of physics but to apply them in some practical investigation. The students work in groups of two or singly. The notebook requirements are few as each group when through with an experiment reports orally. Some of the experiments are adapted to the girls, some to the boys; they are given freedom of selection. References which may be found either in the laboratory or in the school library are given with each experiment.

In describing these experiments, the title and picture will in many cases suggest the nature of the experiment. Although nearly all are old experiments, new phases have been introduced in many.

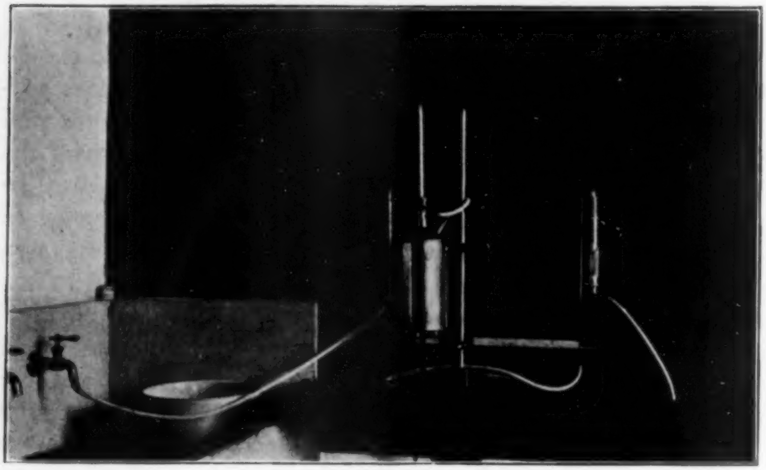
1. Heat of Combustion of Gas.

The apparatus here used is a Junker's calorimeter and a Thorpe gauge. From the change in temperature of a known mass of water as it passes through and the gas used, the number of B. T. U. per cubic foot of gas is computed.

2. Gas Stoves and Kettles.

One cubic foot of gas is used in each test and the heat obtained in the water computed. Considering the input as 600 B. T. U., the efficiency of burner and kettle is determined. Tests are made so as to compare high and low flames; inner and outer flames; tin, granite, and aluminum vessels; covered and un-

covered vessels. The cost of 1,000 B. T. U. obtained under highest efficiency conditions is computed.



3. ELECTRIC STOVE.

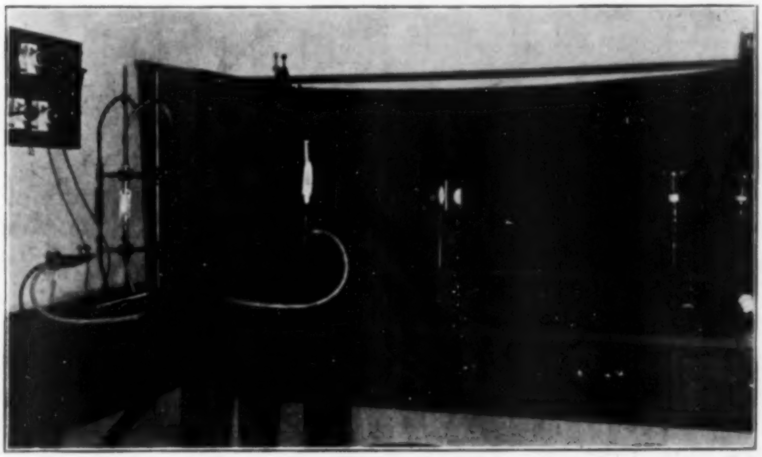
An electric hot plate of three heats is used. The efficiency at each "heat" is determined. From the relation that 1,055 watt-seconds is equivalent to one B. T. U., the input is determined. The cost of 1,000 B. T. U. obtained under highest efficiency conditions is computed. Comparing this result with that obtained in the previous experiment, the relative cost of gas and electricity as a fuel is shown.

4. ELECTRIC FIRELESS COOKER.

The efficiency and cost of 1,000 B. T. U. is determined as with

the exposed electric hot plate, and the results compared and conclusions drawn. A mass of hot water is then placed in the

cooker and left for a few hours. From the heat lost, the current and cost necessary to maintain a constant temperature in the cooker is computed. On the following day the same mass of water is heated on a gas stove of known efficiency to the same temperature and then left to cool through the same period. From the heat lost, the cost of the gas that would be necessary to burn to maintain a constant temperature in the vessel is computed.



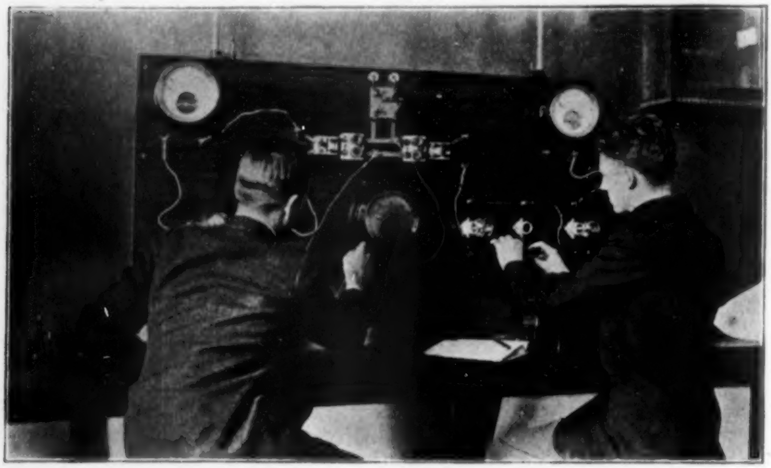
5. Gas Lights.

The apparatus is a Bunsen photometer in a dark room. A tungsten lamp of known candle power is used as the standard.

The gas passes through a Thorpe gauge so that the cost per candle power hour can be computed. The jet flame and different styles of mantle lights are investigated.

6. Electric Lights.

The candle power is determined as in gas lights, the ammeter and voltmeter read and the cost per candle power hour computed. Carbon and tungsten lamps of different capacities are tested. Also used and fresh lamps of same capacity are investigated.



7. Lamp Resistance.

This experiment contains two yarts. The first part is to find the resistance of different carbon and tungsten lamps by the voltmeter ammeter method. Fresh and used lamps of same capacity are tested.

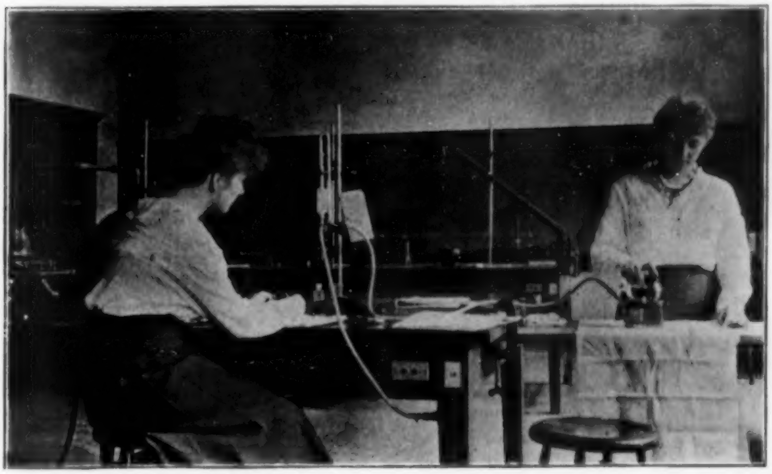
The second part is to determine the effect of temperature on resistance of carbon and tungsten. A 50-watt and two 100-watt carbon lamps are connected in series and the resistance of the 50-watt lamp determined as in part one. One 100-watt lamp is now removed from the circuit and the resistance of the 50-watt lamp again determined. It is now at a higher glow and thus higher temperature. The second 100-watt lamp is then removed. To test tungsten a 60-watt tungsten is used in place of the 50-watt carbon.

8. Lamp Connections.

Three 50-watt carbon lamps, the resistances of which have been determined, are connected in series with the ammeter. The

voltage across different terminals is obtained showing relation between fall of potential and resistance. From the amperage and voltage necessary for the lamps to give full illumination thus connected, the amperage and voltage necessary for a residence of 40 such lamps connected in series and the cost for one hour with all lamps in service is computed.

The same test is made with two lamps connected in parallel. The cost for one hour of the 40 lamps of the residence connected in parallel is computed. The student draws a diagram or floor plan of a dwelling, preferably his own home, showing the



connections of all lamps. The kind and capacity of the lamps is specified and the cost of all lamps in service for one hour computed. This experiement is in part similar to one in the *Laboratory Manual* published by John Wiley and Sons.

9. Light Efficiency of a Lamp.

The first part of the test is the usual experiment of determining the number of watt-seconds equivalent to one calorie by measuring the heat obtained from an electric lamp submerged in water. In the first test a metal calorimeter is used so that all of the electrical energy is converted into heat. In a second test a glass vessel is used thus allowing the light energy to escape. By comparing the two results the amount converted into light energy is obtained which compared with the total electrical energy supplied gives the light efficiency.

10. Gas Flatiron.

The gas used by the iron is measured by a Thorpe gauge. A

dampened towel is weighed before and after ironing. The output is represented by the heat necessary to vaporize the water lost by the towel. From the gas used the input is known and consequently the efficiency can be computed. The actual cost of the operation is computed.

11. Electric Flatiron.

This experiment is identical with that of the gas flatiron. The instructions here given are similar to those on the electric iron in the Weston Co. Monograph B-4. A voltmeter and ammeter are used to determine the input.

12. Dynamo Study.

The dynamo used is a 500-watt capacity, direct current, shunt wound generator. A rheostat and an ammeter are placed in the field circuit. It is run by an induction motor on the same shaft. Forty-watt, 30-volt tungsten lamps are used for the external service. A voltmeter and an ammeter are also supplied for use on the external circuit. The student first makes a diagram showing type of dynamo and connections of all instruments. A voltmeter is connected and a test made with the field circuit open. The action of the rheostat is tested. The rheostat is adjusted so that the voltage is 30. Different combinations of lamps are then connected for the external circuit and the voltage and amperage read. A few questions with the instructions makes this an instructive study of the dynamo.

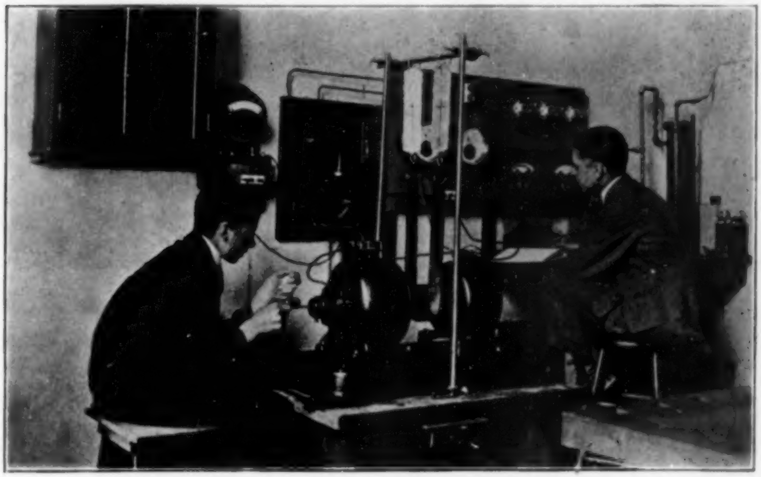
13. Electric Motor.

A half horsepower induction motor is used. Meters are sup-

plied to determine the input. The output or horsepower is determinated by the brake test. The efficiency is determined at two different loads.

14. Water Motor.

A one-sixth horsepower countershaft geared motor is used. The brake test is used to measure the output. A pressure gauge is placed on the water supply so that by weighing the water passed through in a definite time the input may be computed. The horsepower and efficiency at each pulley is determined. From these results the efficiency of the gear is computed.



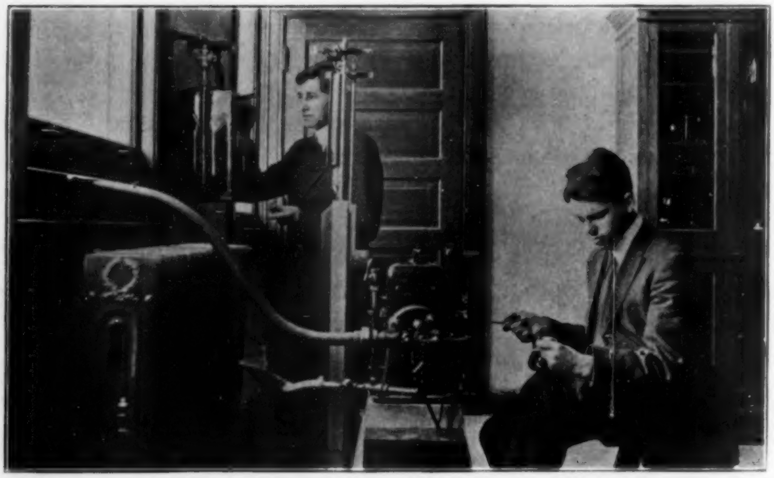
15. Gas Engine.

This was originally a one horsepower, four-cyle, gasoline engine. The needle valve was closed permanently and a gas bag connected to the air intake so that the fuel used is illuminating gas, which is measured by an ordinary gas meter. Under these conditions the engine develops about a half horsepower. The students make a sectional diagram of the engine and explain action. Also a diagram and explanation of the governor. The brake test is used to determine the output. From the gas used during the minute of test the input and the efficiency are computed. The engine has given perfect satisfaction and is a popular experiment with girls as well as boys.

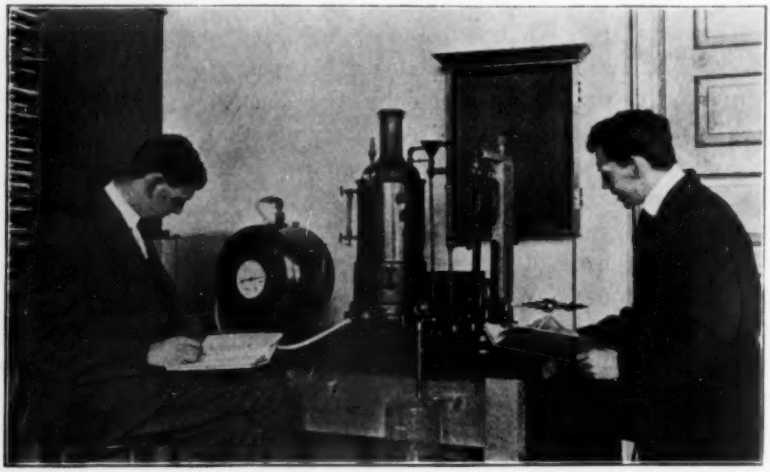
16. Steam Engine.

The engine is a quarter horsepower. Gas is used as the fuel,

which is measured by a meter. The developed horsepower at the crankshaft is determined by the brake test. From the dimensions of the cylinder, the number of revolutions per minute, and the pressure, the work done in the cylinder or indicated horse-

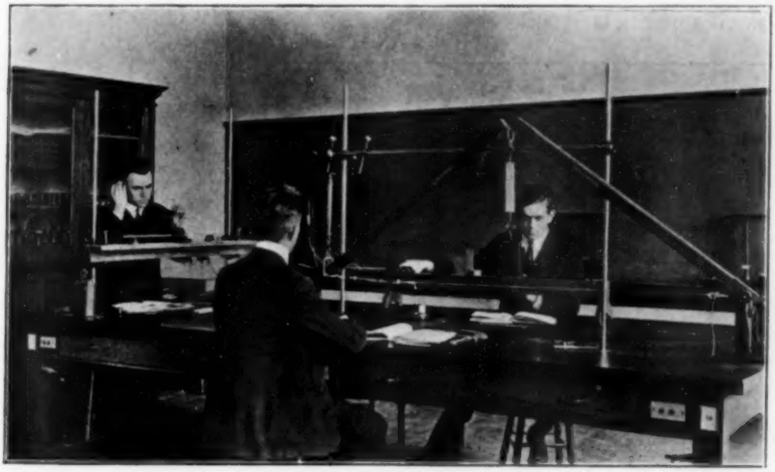


power is computed and the mechanical efficiency determined. From the heat value of the gas consumed and its mechanical equivalent the input of the engine is obtained. This compared with the indicated power will give the efficiency of the boiler and with the developed power or output will give the efficiency of the steam plant.



17. Roof Truss.

A known weight is suspended from the apex. The vertical compression and tie tension resulting at one end of the truss is measured by spring balances. From the angles and weights involved the same compression and tension is determined graphically by the parallelogram of forces. The same test is made with the weight suspended from the center of one of the members. A problem is given to find the additional compression on the walls and tension on the beams when a specified roof is covered with six inches of snow. This experiment is similar to one in the *Laboratory Manual* published by Wiley and Sons.



18. Tensile Strength.

The usual apparatus with sliding frame and wedge-shaped block. The tensile strength of brass, copper, steel, and black and white thread is determined. A problem is given to find the supporting capacity of a suspension bridge using the tensile strength of steel determined. The dimensions given are approximately one-tenth of those of the central span of the Brooklyn suspension bridge.

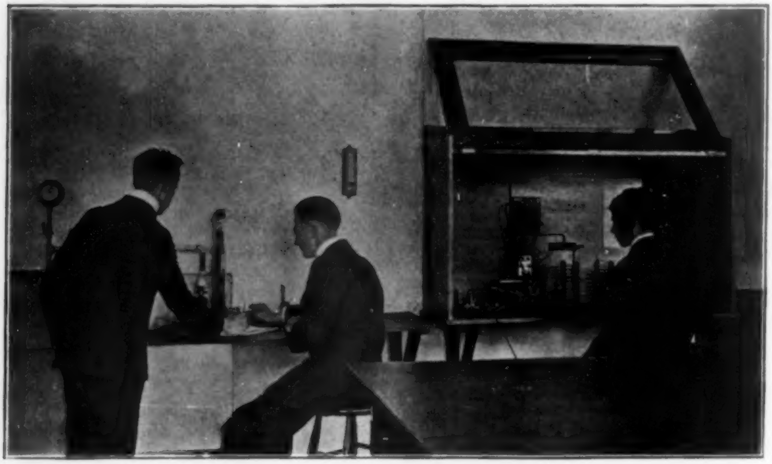
19. Beam Bending.

A micrometer screw in circuit with a telephone receiver is used for obtaining readings. The stiffness of two beams of different dimensions but of same material is determined. The same relation is obtained by applying the stiffness factor. Test-beams of different kinds of wood are supplied. Using the results of the test and the stiffness factor, the supporting capacity of beams, 2 in. x 10 in. x 12 ft., is computed, the bending not to

exceed one-eighth of an inch. With a safety factor of six, the number of beams necessary to support a 500-pound piano is determined.

20. Wireless Telegraph.

One aerial is placed on the ceiling of the laboratory, a second one on the ceiling of the lecture room. The equipment of the station in the laboratory is our regular wireless apparatus which will also connect through another switch to an aerial on the roof, 175 feet long and 75 feet above the ground. The equipment in the lecture room is largely home make. Copies of the International code are supplied and the students transmit and receive. Adjustments of helix, tuning coils, and condensers are varied or tuned until best results are obtained.



21. Telephone.

A wire is strung from the laboratory to the lecture room. A battery call telephone is placed at each end. The box can be opened so that all connections can be traced. A complete diagram is required.

22. Telegraph.

The wire from laboratory to lecture room at each end passes through a double pole double throw switch. One throw connects the telephones on the line, while the other throw is used for the telegraph system. Daniell cells are used for the line batteries, dry cells for the local circuit. Copies of the Morse code are supplied that the students may transmit and receive. If any time conversation is desired, it is understood that six shorts is to throw the switch to the telephone side and use the phone.

THE VITALIZING OF HIGH SCHOOL CHEMISTRY.

By A. E. Wood,
State Normal School, Florence, Ala.

What I am going to say on this subject is based on two convictions as to what high school chemistry should do for the student. In the first place a study of chemical principles and the practical application of these principles should give the student a better living acquaintance with his everyday surroundings, and in the second place the student should develop the experimental method of attacking problems and securing results.

It will probably be admitted that high school chemistry as presented in most of our secondary school texts is one of the most difficult subjects in the curriculum. A student's previous work may have been excellent in many ways and he may have done laboratory work successfully in some other subject, yet when he begins the study of chemistry he encounters many difficulties. He has to adapt himself to a new subject in new surroundings. He has to learn the names and formulas of many substances of which he has never heard. He has to learn a number of hypotheses, theories and laws to account for chemical facts. He has to learn to observe and interpret at the time of carrying out his experiments. These are a few of the things we expect of the average immature overworked high school pupil.

What then can we do to vitalize the teaching of chemistry? Let us first look to the recitation. The recitation should become a clearing house for the troubles encountered in the experimental side of the work. The various facts and principles should be brought out so that they can be grouped into a few large units for otherwise the student will retain but very little of the subject matter presented to him. Dr. Ira Remsen has said, "It is an easy thing to teach chemists chemistry, but it is very hard to teach beginners something that is worth while about chemistry in one year." Later on in the same article, Dr. Remsen laments the fact that we make too many fleeting impressions with no reminders, that we attempt to cover too much ground and that we do not introduce enough drill work such as is characteristic of the languages and mathematics. These facts lead me to believe that the first step in the vitalizing of high school chemistry should be in developing a good live recitation. In the theoretical discussion of the text I frequently find it necessary to reword and reinterpret what the author says. I sometimes outline the more difficult

lessons or ask a few questions which will lead to the most important thoughts.

Another good way to vitalize the subject is to call attention whenever possible to the application of chemical processes in the commercial world. The main difficulty here is that the high school student's knowledge of the commercial world is limited. Our more recent textbooks are doing a great deal for us in this direction so that it is becoming increasingly easier to relate the chemistry of the classroom to the chemistry of the outside world. And then, too, a great many industrial plants are glad to present samples showing the various stages in the manufacture of their products. Collections of this kind should be made and shown to the class at the proper time. The Corn Products Refining Company of New York have an interesting educational exhibit on corn and its products; likewise the American Cotton Oil Co. on cotton and its products; Belding Bros. & Co. on the manufacture of silk; The Dixon Pencil Co. on the manufacture of a lead pencil, etc. There are a large number of others that could be mentioned.

Another very helpful means of securing interest in places where industrial plants exist is to visit such places as will show chemical and other scientific processes in operation. Florence is a small town but we are fortunately situated in this respect, for we have several interesting places to visit. Among them may be mentioned the iron furnace, oil mill, cotton mill, ice plant, gas plant, steam laundry, wagon factory and stove foundry. Before making the trip, the class is given an outline of chemical and whatever other important scientific processes are involved. They are then taken through the plant where they make their own notes and afterwards write up an account of the trip in their notebooks so that it will become a part of their permanent laboratory record. With us these trips are made after school hours. The students are urged though not required to go. Out of a class of seventy pupils in no case so far have less than sixty pupils attended, and in one case, the visit to the ice plant, every member of the class was present. This shows that they are interested in this phase of the work.

Another most important way to vitalize the work is in the laboratory. In my own case during the first half of the year I give a series of experiments covering the fundamental principles, experiments such as will be found in almost any good secondary manual. During the second half of the year experiments of a

practical nature are introduced such as the making of safety matches, gunpowder, soap and a large number of the simple food tests. In every case I try to avoid introducing an experiment which employs a test which the student can not be expected to understand.

These are a few of the ways in which I attempt to vitalize the work and while I have by no means reached the goal for which I am striving, I can not help but feel that with each succeeding year a course is being developed that is more worth while from the standpoint of the high school pupil.

FADS.

One hears nowadays so much about the subject of fads that he is sometimes disgusted and at other times puzzled to understand just what is meant by the term. In the opinion of the writer there is no such thing as a fad, yet for the benefit of those who would like to see a definition of the word, here is one from the writer's point of view. A fad is that for which the person so calling it has no use, either theoretical or practical, but for which the person studying it has use, in order to earn his daily bread.

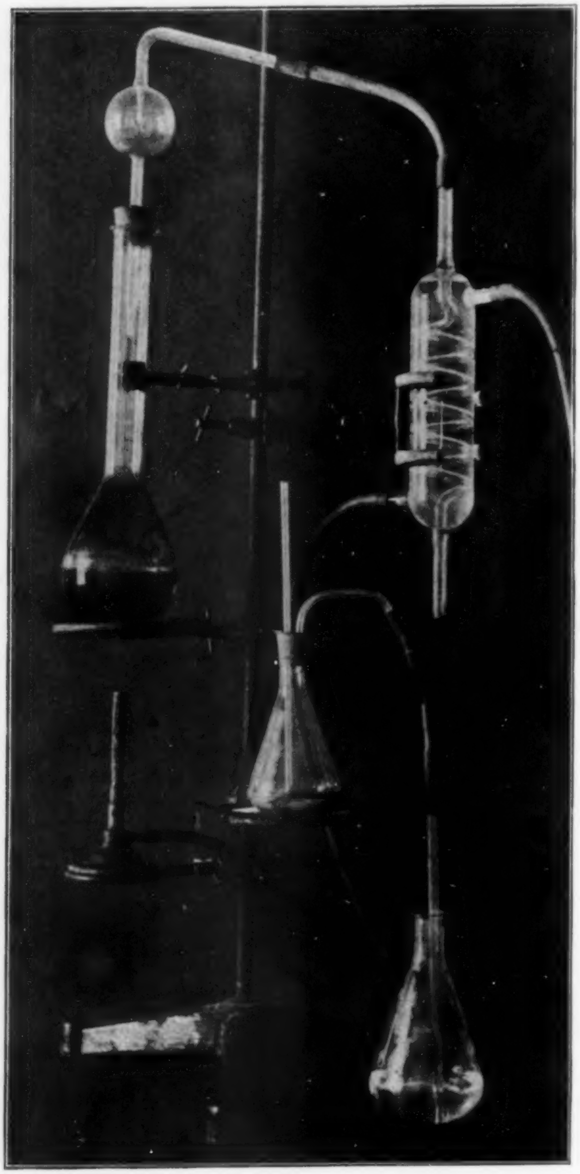
Many people have the impression that this is not a cosmopolitan age, and that in our large centers of population people do not have many varied ideas or conceptions of education. This is a mistaken idea, because in large congested centers of population there are very many ideas as to what education comprises. There are numbers of people who desire to become proficient in this or that subject, which to others appears to be absolutely worthless and of no educational or economic value. In the high schools of every city of at least 100,000 inhabitants, provision should be made in the curriculum for giving instruction in every subject for which there is a considerable demand. The writer means by a considerable demand, say a desire on the part of at least fifteen individuals, and he would advocate instruction, where there is this demand, in subjects which our conservative friends would designate as fads.

Our schools are not supported primarily for instruction in Greek and French, mathematics and science, but for the purpose of training our boys and girls to become useful citizens of such a type that they will do something to add to the economic, social and intellectual worth of our country. If one is interested in mechanical drawing and has no ability in languages, arrange his course so that his major study is mechanical drawing. If a person demands instruction in practical electricity, arrange matters so that the bulk of his time will be spent on the subject in which he is vitally interested. If he wants mathematics and has an aptitude for that, give him mathematics. The contention of the writer is that the best and most efficient results are secured in the long run by developing the individual in those directions in which he has a special aptitude.

A KJELDAHL SAFETY TRAP.

By Hilton Ira Jones,
Dakota Wesleyan University, Mitchell, South Dakota.

In making the Kjeldahl determination two dangers confront the amateur. The one is the danger of the alkali getting into the



acid through foaming or the alkaline spray being carried over. This danger has been overcome by the use of improved Kjeldahl bulbs. The other danger is that of the acid drawing back into the alkali. Often the student adds the alkali too fast when he is neutralizing preparatory to distilling. Great heat is generated with the result that the acid is drawn back as soon as the cork and bulb are inserted. Sometimes the same thing occurs by the fire going out during the process of the distillation. Very few students beginning this most important determination do not have trouble with the drawing back of the acid.

The accompanying illustration shows a clever little device arranged by one of my students, Erskine Robertson, to overcome this trouble. The smaller flask, shown set up with the glass condenser for purposes of illustration, contains mercury. The long tube dips just beneath the surface of the mercury and the other just passing through the cork is connected by a Y-tube to the lower end of the condenser. This simple device entirely overcomes the difficulty. It can be permanently connected to the regular Kjeldahl condensers.

It is possible that a small amount of ammonia gas might enter this safety flask and give low results. To obviate this, the trap is blown out before titration by blowing through the long tube. In regular practice we find this safety trap very convenient because with it we can interrupt a Kjeldahl determination at any time without loss or danger, instead of being forced to complete the distillation when once it is begun. This means a great deal to the busy teacher who must continually interrupt his analytical work to attend to his classes.

CLASS ROOM SAYINGS.

Name the great use of the barometer.

A.: A barometer is used to phrofisies the condition of the weather.

The name of the medicine* supposed to fill all space is called ether.

*Medium.

Inertia is a shark or jar.

Suffocation is a leak of oxygen.

Cohesion is the acting of the maly. (molecules) of the air at small distances.

Rain water is impure because it gathers impurities on its way from heaven.

CHARLES' LAW APPARATUS.

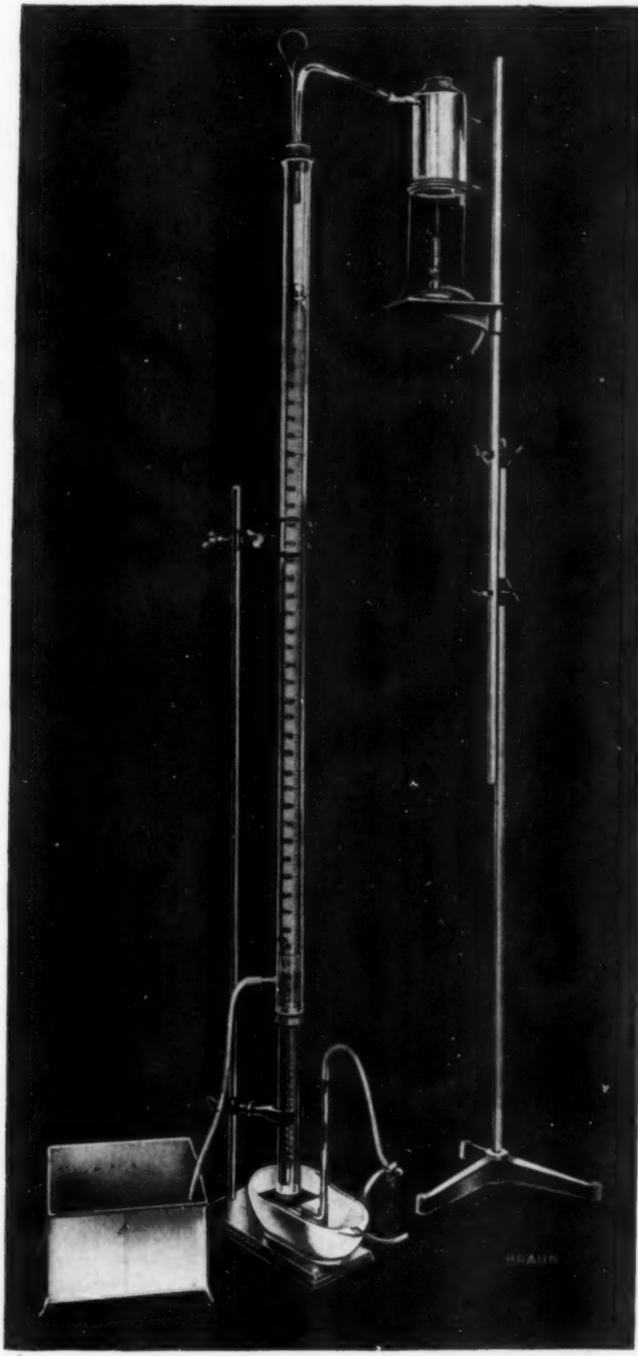
By C. W. Gray,
Hollywood High School, Los Angeles.

The apparatus was designed to give the student an experiment on Charles' Law that would give direct visible results and would require the least mathematical calculations possible. The pressure is kept constant and the student can see the volume vary as the absolute temperature varies.

The apparatus consists of a carefully graduated tube which is raised and lowered into a mercury well. In order to raise and lower it and keep the pressure in the tube constant, a rubber tube runs up through the mercury into the graduated tube. By sucking or blowing on the other end of the rubber tube the volume of the air in the graduated tube can be varied as desired. Covering the graduated tube is a larger glass tube and into this tube the vapors from the boiling liquid are passed to give the desired temperature.

The student first takes the room temperature and converts it to the absolute scale. If the room is 20°C. he has an absolute temperature of 293°A. The graduated tube is then raised or lowered until the volume of air in the tube corresponds to the absolute temperature of the room, 293 in this case. The rubber tube is securely closed and steam is passed into the apparatus. As the air in the graduated tube is warmed and expands, the tube must be slowly raised. It requires two to do this—one to raise the tube as directed by the other who watches the surface of the mercury columns. As soon as the volume is constant, adjust the mercury columns and take the reading. The temperature of the air is now 373°A. if at sea level, otherwise make the necessary corrections. On taking the reading, the volume is found to be 373 showing that the volume varied directly as the absolute temperature.

A good firm stand should be made to hold the apparatus as it is rather high and a shelf near the top is needed to hold the steam generator and burner. Be very careful not to raise the graduated tube above the mercury for after it is used for the first time a little water is always on the surface of the mercury and if any of it gets into the tube it will be necessary to dry both the tube and the mercury. If other temperatures are desired, liquids with different boiling points may be used. In that case the lower outlet tube is connected to a condenser for con-


BRAUN

densing the vapor. If a lower temperature is wanted, the tube holding the mercury must be made long enough to extend to the top of the apparatus and ice water circulated between it and the outside tube.

If you have a good assortment of glass tubing you can make an apparatus without much trouble. First make your graduated tube and the rest of the apparatus can be made to fit it. The apparatus can be bought of the Braun Corporation of Los Angeles, Cal.

SCHOOL MEDICAL INSTRUCTORS.

What a splendid idea it would be if Boards of Education who have jurisdiction over the larger high schools in our country, would see their way clear to appoint to the faculty a medical man or woman, whose entire time would be given to caring for the health of the pupils in the schools with which he might be connected. This scheme carries with it the idea of having in the school building a well-equipped hospital and rest room. In this place the physician would be enabled to examine all pupils as to their physical condition, giving advice as to what should be done where physical defects and diseases are discovered. We all know that the physician would find a large percentage of pupils afflicted with some disease or other. The jurisdiction of the physician,with functions as mentioned above, would undoubtedly cause the health of the student body to be greatly improved. Then, too, there would be on the ground a competent person to attend any pupil who might be taken suddenly ill, or who might suffer an accident. To be sure, there are many cities which have school physicians, but they come and go at irregular intervals, and are at the school for only a comparatively short time. The work that they do is, of course, of great worth, but the scheme mentioned here would be of much greater value and would be productive of far-reaching and lasting results.

INTERFERENCE MEASUREMENTS OF WAVE LENGTHS IN THE IRON SPECTRUM (2851-3701).

Owing to the increasing demand, on the part of astronomers, chemists, and physicists, for accurate values of the wave lengths of the lines in the spectra of iron and other elements, the Bureau of Standards has taken up the work of determining standards of wave length. This work is being done in accordance with the recommendations of the International Wave Length Committee. The spectograms were obtained in Marseilles in the laboratories of Buisson and Faby, the pioneers in this work. The plates were measured at the Bureau of Standards. This is rather a difficult region of the spectrum to observe, lying entirely in the ultra-violet. Apparatus necessary to do this work has recently been installed in the Bureau of Standards, and wave length determinations of the highest accuracy are being made throughout the spectrum, including those rays which are too short to be visible and also those which are longer than any that the eye can see.

A pamphlet upon this subject has just been issued as *Scientific Paper, No. 251*, copies of which may be obtained without charge from the Bureau of Standards, Washington, D. C.

PLANT CHIMERAS AND THEIR RELATION TO HEREDITARY PHENOMENA.[1]

(*Abstract.*)

By D. M. Mottier,

Indiana University.

Vegetable chimeras, known also as graft hybrids, are plants of a hybrid nature, which, however, have not arisen through seed production, but as adventitious shoots springing from the callus formed at the juncture of stock and scion in grafting. Two classes of chimeras are recognized, sectorial and periclinal. In sectorial chimeras the tissues of the two parents or members, stock and scion, are united side by side in the growing point, so that the parts of the chimera resembling the respective parents may be separated longitudinally. A periclinal chimera is one in which the center of the plant consists of tissue of one parent overlaid by a layer of tissue of the other plant from one to two, or possibly more, cells in thickness. In the latter case the individuals may often bear the most striking resemblance to real hybrids, being complete blends between the two parents in both vegetative and reproductive parts.

Chimeras have been known for about 270 years. Probably the first on record was produced in Italy in 1644, between the citron and an orange, the fruit resembling an orange with a sector of citron. Such fruits were called Bizarrias because of this peculiar appearance. In recent years similar chimeras have been reported as originating in Florida between the orange and grapefruit. A very beautiful chimera of recent origin is that of an apple produced by Prof. W. E. Castle of the Bussey Institution by grafting a "Boston stripe" upon the "golden russet." In this case the stem end or half of the apple is russet, while the blossom end is of the "Boston stripe." Among the more famous chimeras or graft hybrids may be mentioned the much-discussed *Cytisus Adami* which originated near Paris in about 1826. This was said to have been produced as the result of a graft between *Cytisus purpurea* and the common laburnum, or golden chain, *Cytisus laburnum*. Another is the whitethorn medlar, *Crataego-Mespilus,* which is said to have originated near Metz, Germany, by grafting the whitethorn, *Crataegus monogyna,* upon the medlar, *Mespilus germanicus*. As the above-mentioned species do

[1]Read before the Indiana Convention of Science and Mathematics Teachers, Indianapolis, March 6, 1915.

not cross, the origin of these wonderful and perplexing forms remained a matter of speculation until a few years ago, when Professor Hans Winkler produced chimeras experimentally between the common nightshade, *Solanum nigrum,* and the tomato, *Solanum lycopersicum.* Using the cleft method of union, Winkler grafted shoots of the seedling tomato upon the stem of the nightshade. As soon as union had taken place, the scion was cut near its base in such a way that the cut surface consisted partly of nightshade and partly of tomato tissue. Of the adventitious shoots arising, only those which sprang from along the line of the union of the two specifically different tissues were allowed to grow. Among a large number of adventitious shoots, about 3,000 in all, several were found which gave the desired result; i. e., they were apparently hybrid in character. Some resembled more closely the nightshade, some the tomato, while still others were intermediate as to foliage, flower, and fruit. A number of these were planted as cuttings and were grown to flower and fruition. A few set seed, while others developed fruit but no seeds. The seeds of one of them, which Winkler named *Solanum tubingense* and which more closely resembled the nightshade, developed into pure nightshades, while those of another, *Solanum proteus,* more closely resembling the tomato, gave pure tomato plants. Although Winkler had produced experimentally plants that were hybrid in appearance, inasmuch as the two plants were wholly blended, yet it was clear that they were not real hybrids. The real explanation was still to be found. This was accomplished by Professor Erwin Bower of Berlin, who discovered the key to the situation in his study of the tissues of a variegated geranium. Plants which bear green leaves with white borders are well known. Such leaves are due to the fact that the green central part of the leaf tissue is covered over by a layer of colorless tissue two or more cells in thickness, and the thin edges of such leaves being, as a consequence, made up of colorless cells exclusively. Thus the colorless tissue covers the leaf as a glove covers the hand. Now it is supposed that in the growing point from which such leaves spring, a layer of white (colorless) cells covers the green tissue beneath, and a leaf originating from such growing point will consist of green cells within and white cells without. Likewise, in the formation of a terminal bud at the juncture of the two parental tissues of the graft, the tissues of one parent, whether stock or scion, by growing a little faster, may soon cover that of the other parent, and the result will be a

shoot composed internally of cells of one parent with a covering made up of cells of the other parent. This results in a periclinal chimera. If, on the other hand, one-half or a sector of the terminal bud be formed wholly of cells of one parent, the parts of the resultant shoot resembling the respective parents can be separated longitudinally, and the result is a sectorial chimera.

Winkler's apparent hybrids were, therefore, periclinal hybrids. For example, his *Solanum tubingense* was a periclinal chimera in which the inside of the plant consisted of nightshade overlaid with one layer of tomato tissue, since the seeds produced gave pure nightshades. It will be remembered that the germ cells or spore-bearing tissues are derived from the sub-epidermal cells. On the other hand, *Solanum proteus,* resembling more closely the tomato, and whose seeds produced pure tomato plants, is a periclinal chimera in which the interior is nightshade with a covering of tomato, two cells in thickness. Two other chimeras were developed, namely *Solanum gaertnerianum,* consisting of tomato on the inside and a two-celled layer of nightshade on the outside, and *Solanum koelreuterianum* with only one layer of tomato cells on the outside.

From the foregoing, it is clear that these plants are not hybrids, inasmuch as their seeds do not give plants of a hybrid character; they are truly chimeras. However, Winkler obtained one plant which, if his observations are correct, seemed to be a real hybrid. This, the fifth produced, he called *Solanum Darwinianum.* In *Solanum Darwinianum* Winkler claims that 48 chromosomes were counted in the reproductive cells, this number representing one-half the total number of chromosomes for the two parents, namely 96 (24 in the tomato and 72 in the nightshade). If this be correct, nightshade and tomato cells, or some of them, must have actually fused in the process. *Solanum Darwinianum* seems, therefore, to be the only real graft hybrid in the world.

If it be possible to produce by the process of grafting a cross between two species that cannot be made to cross sexually, to what extent and in what manner will this fact influence current conceptions of heredity? Careful investigators, though receiving new ideas with sympathy, will, no doubt, accept Winkler's conclusions with much reserve if not with skepticism, and this they should do until his statements are verified. Every experienced cytologist knows that an accurate counting of chromosomes where they are present in large numbers is a very difficult task, and results based upon scanty material without verification cannot be regarded as strictly reliable.

If it be established beyond all doubt that real graft hybrids can be produced, the field of the florist and horticulturist will be considerably widened. The possibility of combining strains that do not cross is at once apparent, and, as vegetative propagation would naturally be easy, the new blend obtained will be easily kept pure and constant because of this mode of propagation. It is conceivable that many of the ends sought in crossing, such as increasing resistance to disease, to severe climatic conditions, etc., the improvement of quality of fruit, foliage, etc., may be reached in the development of graft hybrids. However, because of difficulties encountered, it is equally possible that little more than the production of a few interesting freaks will be the fulfillment of the experimenter's happiest dream.

As to the effect upon present conceptions of hereditary principles, little is to be expected. The discovery of parthenogenesis did not overthrow the theory of sex in plants, nor did the presence of apogamy in ferns upset the doctrine of antithetic alternation of generations in the higher plants. Far from working mischief, these singular phenomena did much toward modifying the rigidity of certain fixed conceptions, and of making more flexible principles of thought that tend to a sort of dogmatic rigidity.

In conclusion, sex hybrids which bear striking resemblances to chimeras, such as appear in plants of variegated foliage should not be confused with real chimeras. Chimeras are not hybrids at all. It would be just as proper to speak of the numerous variegated coleus varieties, which are due merely to bud variation, as chimeras, as to place sex hybrids, which owe their variegated character to crossing, in the category of chimeras.

SISSON TELEGRAPH COMPANY.

The Sisson Telegraph Company, an organization composed of students of the Hyde Park High School, Chicago, is now operating a telegraph line connecting twenty-five stations with the Hyde Park High School. The main line extends from Forty-second to Sixty-seventh Street and is using over twelve miles of wire connecting different students' outfits with that of the school.

The line was founded and erected by Baird W. Sisson with the assistance of other students, and has been in operation for four years. It is connected with several wireless stations and distributes the correct time and current news.

BIOLOGY AS A UNITY COURSE IN FIRST YEAR SCIENCE.

By D. O. Robinson,
Eugene High School, Eugene, Oregon.

Unsettledness of Science.

The fact that I have been able to compile a bibliography of over one hundred references to magazine articles on the subject of "General or First Year Science" is pretty good evidence that there is considerable unrest in this department. Besides, I have five recent texts and three outlines for such a course. These articles date back fifteen years or more, which shows that the need for changes in science teaching are not new.

There are several reasons for this state of affairs in science work among which the following are chief—the changing needs of preparation, the inadequateness of physical geography and the recognition of the laboratory method in science presentation.

Changing Needs.

The needs of the high school course have changed greatly in the last ten or more years. This period has seen the general introduction of manual training and domestic science. Also the acceptance of a wider and elective course of study.

The life of our people has changed. We are fast becoming an urban nation. Many things which were once mere matters of daily observation (in the country and open fields) are now not known at all by the growing youth unless his attention is especially called to them, and more particularly the home environment of today does not give the incentive of responsibility that was formerly given on the farm. This is one of the things we are trying to do in our school shops and laboratories.

Because of these changes, the whole science curriculum is undergoing pressure demanding a change. In most places this pressure is felt most keenly in the first year course. There is a more general acceptance of the subject material of physics, chemistry and botany than of most of the subjects now offered for first year work. Beside the applied courses are demanding somewhat of a scientific grounding at least, in method. Most of our present first year science does not give that because they are largely descriptive.

Physical geography has had a decided grasp on the situation in the past and we find it, at present, established in the first year in many states. Changes in grade teaching, with a very great improvement in the teaching of the physical aspect of geography

in connection with general geography and a change in the method of science teaching in the high schools to a laboratory presentation have made physical geography less desirable as a first year subject.

LABORATORY METHOD.

The past few years has also seen the acceptance of the laboratory and inductive method of science teaching as sound pedagogy and the application of such methods generally introduced in high school. Because of this, efforts have been made to adapt the laboratory method to the subjects in the sequence as it stood. Those subjects having an elaborate and complicated laboratory material are found unsatisfactory in the first year. So the subjects which have held a place in the first year are not as effective as could be desired. I will try to show some of the reasons why later on.

SOLUTIONS.

While there are several solutions to the science situation, I think that only one of them offers a general solution for the conditions in Oregon. I will mention the junior high school and a two year general course with objections and make my plea for a broad, adaptable, unified course.

The junior high school as a solution of this problem is the ideal solution, to my way of thinking, but it does not fit present needs. So far as my knowledge goes there is only one junior high school in Oregon. That one is at McMinnville. Superintendent Rutherford says that the junior high school will be pretty generally established in Oregon in three years. I fear that he is too optimistic. Educators are too conservative. Anyway, if we accept the junior high school as our solution, I should have to write an entirely different paper because the whole course of study beginning with the seventh grade would have to be rewritten, including three years of science adapted to the age, type of mind and development of the pupils, as well as the other subjects in the course.

A TWO YEAR COURSE.

Passing up the junior high school as not coming in the province of this paper, there are then two solutions within the present system that I should like to discuss. The first one is a two year required consecutive course in science. The present tendency is rather toward a more elective scheme and shorter courses rather than longer. The one year course has been and

is the almost uniform maximum unit. Besides, at present, many schools are offering credit for many subjects of less than one-half a unit. So that while a two year course would, if properly outlined, give a broad grounding in science, those schools that have accepted the N. E. A. course of study will find a two year requirement in science hard to enforce.

UNIFIED COURSE.

The feasible course then for a first year science is a broad unified science, easily adaptable to laboratory methods. The method of learning to do by doing is beginning to be recognized as a great factor in the development of the pupil at this age (twelve to fifteen) or even at the beginning of the junior high school age. The science selected should be such as will readily lend itself to a broad application of self-education by experiment and observation. This is my understanding of the report of the Committee on General Science to the Oregon Teachers' Association:

"The committee is inclined to recommend that general science be made optional in those communities in which it is possible to secure a teacher capable of handling the subject so as to make it meet the needs of both community and students. This is a matter in which every step should be a sure one, and we should proceed with sufficient deliberation to avoid mistakes.

"The committee's extensive correspondence indicates that the *aim* of the course should be (1) to furnish interesting and useful information, so as to hold the pupils in school and acquaint the child with his relation to the natural phenomena; (2) to aid those who have a taste for science to choose their future work intelligently.

"*Place in Course:* Almost unanimous agreement places the course in the first year of high school, as a required subject with the possible exception of those preparing for colleges, although some colleges, as University of California for instance, will accept general science for admission. Most agree on a two semester course, widest range is from one to four semesters.

"*Method of Instruction:* The method of instruction should be both descriptive and experimental, with emphasis on the latter.

"*Content:* Physics, chemistry, earth science and biology should form the basis of the course; local conditions to determine the proportion of each, as well as the other branches used."

These requirements are best met by a science whose unity is biology (plant and animal) with enough of physics, chemistry,

earth science and agriculture included to explain the underlying principles of the unifying topic.

Outline: Some of the main topics of the outline would be as follows:

1. Oneness of Life—Structures and Processes.
2. Environment—Physical and Chemical.
3. Fundamentals of Structure.
4. Fundamental Processes—Nutrition, Respiration, Excretion, Growth and Reproduction.
5. Economic Relations—Food, Shelter, and for man, Clothing and Shelter; Disease, Sanitation and Pests.

Objection of General Science.

One of the serious objections to most of the new outlines in general science is lack of *unity*. This is especially true of the texts on the market today. The tendency is to pick out a few smattering physical facts here, some chemical data there, etc., and call it general science. The advocates claim to be trying to give an insight into the various subjects. However, none of them cover simply the main ground plan of the various sciences. Some attractive facts or data have been selected and presented. Much of it, it seems to me, is presented without the proper correlation or groundwork of knowledge of laws to make it clear or valuable. For example, the whole explanation of gas pressure seems to me too much to give in an elementary course simply to understand gas meters. I have found considerable difficulty in getting third and fourth year pupils to have a clear idea of this particular subject.

There is another factor in general science that must be reckoned with. "We need more and better science, not less,"[1] but many students will be apt to feel that they have the essentials of all science and the course in general science will be all that they will take. In this case we will be much worse off than when the student has a fair knowledge of one or two sciences and *knows* that he does not know the other sciences. We will be much better off sticking to the present system of several sciences and giving them in a scientific, laboratory method.

Another objection to general science is the bias of the teacher. The field is too broad to be covered in a year and the teacher will teach those parts in which he is interested, omitting or slighting others. Then the course will lose its only merit, that of being *general*.

[1] J. M. Coulter.

ARGUMENTS FOR BIOLOGY.

Already Tried Out: Such a course is not an experiment. At the present time biology is a successful first year high school subject in New York State. The New York State course includes physiology which I believe may well be replaced with topics on the economic relations of plants and animals, especially, hyginem disease and pests. Massachusetts has long used a first year biology syllabus.

I have taught biology under the New York syllabus and know that it can be done successfully, and that the students get a grasp of the fundamentals of the subject. The subject can be taught scientifically to pupils of first year high school age.

Articulation with the Grades: The determination of a first year high school science course should take into consideration the grade work of the pupils. An examination of the state course of study shows that physical geography follows through the grades to the seventh. This outline is fairly definite and furthermore is included in the texts on geography so that with the general observation of physical features at hand a fair understanding of the facts are gained. I have the statement of such authorities as Supt. L. R. Alderman, Supt. C. I. Collins and a number of grade principals that this subject is better taught than nature study. It is my opinion that the first year student has had all the physical geography that he can grasp until a good course in physics has been taken.

Physiology is often used as first year science. Here again I believe that the pupil has had all he can understand until he has had a grounding in physics.

The state course also outlines an excellent course in nature study by Dr. C. F. Hodge. However, it is my contention that the spirit of this course is not carried out and that most of the outline is not given at all. Most teachers are not prepared to teach this kind of an outline. There is no book. In fact just as soon as a book is introduced, the main value of the outline is defeated.

This leaves the pupil as he arrives at high school age open-minded as regards biology, with little information of the laws underlying the great fundamental life processes, in fact, with surprisingly little information about things around them. "Through a series of tests . . . entering pupils (normal) were found amazingly ignorant of the most common plants, vegetables and trees. . . . Their powers of discrimination

were so feeble that they found it difficult to distinguish a potato from a tomato vine . . ."[2]

The data of biology then being new or at least unexplained and within the grasp of pupils of the first year (as physics is not) it is the logical subject to place at that point.

Fundamental: The data of biology is the most fundamental for a youth to have, taking up as it does the vital life processes. Because of their importance, their place early in the curriculum is advisable so as to reach as many as possible. As we all know, there is a considerable falling out of pupils after the first year.

Much of the practical information of biology can be applied in everyday life to the lasting good of the youth. These things in a first year course will be learned at the beginning of the habit-forming period. In fact we would teach the importance of habit-forming as a part of the course.

The problems of nutrition, excretion, respiration, circulation and reproduction should be mastered for both plants and animals and correlated and these in turn correlated with human right living. The life problems of plants and animals touch ours at every point so that it is very desirable to have these impressed on the youth and also those of heredity and environment which we learn in a study of biology such as we have outlined. I believe that a student taking this course cannot help but have a bigger, broader life and be a better citizen.

Laboratory Method: The laboratory method in science is fully recognized as a high school device in teaching. It has proved its worth in every science course.

In selecting a science course for first year pupils, considerable attention should be given to the kind and quantity of material available. My observation and experience with pupils in laboratory leads me to recommend the wealth of natural, simple material of biology for laboratory for first year students in preference to a majority of the toys, models and diagrams of physical geography, physics or chemistry. When we contrast

Barographs with life histories, or
Topographical maps with daily dietary records, or
Parallel of forces with plant culture, or
Falling bodies with fertilizer tests, or
Toy motors with flower analysis,

[2]Dr. Jean Dawson, School Science and Mathematics, Vol. 15, No. 1, p. 33.

for independent thinking and observation the teaching value balances largely on the side of the biological material. Any laboratory can make use of the real materials of biology. In fact, in high school, we are coming more and more to study, in biology, plant and animal relations in contrast to earlier studies of histology. Such problems as the production of a specimen plant having superior qualities, or the most profitable care of stock, have decidedly the claim to the highest merit as laboratory work.

Sometimes when I see even advanced pupils floundering through experiments on coefficient of expansion or latent heat or circumference of the earth, I am not surprised that there is a falling off in the per cent of pupils taking science.

Because of the wide range of material in biology, almost any pupil can do the major part of his laboratory work in problems appealing to his interest rather than a series of cut and dried, forty to fifty experiments of doubtful result as in physics and physical geography.

In a large measure a live class in biology can be taught to supply their own material. They are glad to get out and bring in specimens for class study. So in biology we have by far the most accessible, illustrative, actual and diverse laboratory data of any science.

Unity: Lack of unity is one of the large criticisms of the present new outlines for first year science. It is interesting to note how the new texts follow suggestions and leads to drag in simple exercises. Here is a possible linking; movements of levers, horses pulling, doubletrees, plowing, soil fertility, crops rotation, etc., etc. So in the name of general science *we ramble*.

"The committee[3] maintains that *unity of subject matter in any course in science is of first importance,* by which is meant that the subject matter should be so organized that the appreciation of the *underlying principles* shall form the foundation of the student's knowledge, thus giving him a scientific basis for the organization of his knowledge.

"The committee unanimously agree that a course in elementary science should include a study of the physical environment of living things; and a consideration of plants and animals and man as living organisms; and that throughout the course constant reference should be made to the application of science to human welfare and convenience."

[3]Preliminary report of the Biology Sub. Committee, N. E. A. '14, SCHOOL SCIENCE AND MATHEMATICS, Vol. 15, No. 1, p. 44, Ja. 15.

The course which I have outlined gives many necessary facts, all science fundamental to biology and enough work for a full, interesting year's work with much material crowded out. It all has the unifying thread of the likeness of all life, especially in essential processes and the ecology and economy form interests of wide application and understandable relations to the first year student.

Correlation: The changing demands of education have already been mentioned as a factor in determining the first year course. Here again our unified course with biology as the basis meets more of those needs than any other outline so far offered; direct instruction and reference work may be given on the subject of woods and lumber for the boy in the shop; the caloric value of foods and the hygiene of foods and eating for the girls taking cookery. The whole science of plant growing and stock raising is a direct outgrowth of biological topics.

Conclusion.

I am convinced from my study of the texts on the markets, the needs of first year pupils and my experience in teaching that this kind of a first year course that takes the living things of the pupil's environment and presents them in a simple, scientific way is the most satisfactory that can be offered.

A STUDY OF THE QUALITY OF PLATINUM WARE.

At the suggestion of a Committee of the American Chemical Society, the Bureau of Standards, of the Department of Commerce, has made an experimental study of the quality and purity of platinum utensils such as crucibles, wire gauze, dishes, etc., and has developed a delicate thermoelectric test for platinum purity which permits a rapid estimate to be made of the amount of included foreign matter such as iridium or iron without injuring the article tested. This thermoelectric test is being generally adopted by large purchasers of platinum ware.

The losses in weight on heating and after acid washing have been determined for several grades of platinum crucible including pure platinum, and ware containing iridium or rhodium and also iron. From the results of this investigation it is now possible to predict very closely what will be the loss in weight of a "platinum" crucible when heated, this eliminating a serious source of uncertainty in exact analytical chemistry. Ordinary grades of platinum are found to lose from 0.7 to 2.7 milligrams per hour per 100 square centimeters of surface at 1200°C. Curiously enough the small amounts of iron always present in platinum are found to bear no simple relation to the magnetic properties.

Suggestions are also given concerning specifications for the purchase of platinum crucibles.

Copies of this paper, No. 254, may be obtained without charge on request to the Bureau of Standards, Washington, D. C.

PROBLEM DEPARTMENT.

By I. L. Winckler,
Central High School, Cleveland, Ohio.

Readers of this magazine are invited to propose problems and send solutions of problems in which they are interested. Problems and solutions will be credited to their authors. Address all communications to Dr. Jasper I. Hassler, 2301 West 110 Place, Chicago, Ill.

We are sorry to announce that Mr. I. L. Winckler, who has so ably edited this department during fourteen months, has been obliged to resign on account of an increase in other duties. Under his wise direction the Problem Department took on new vigor and has become more interesting and valuable than ever.

Contributors will be pleased to know that Dr. Jasper O. Hassler, of the Englewood High School, Chicago, Ill., has accepted the management of this department. We feel very sure that there will be no reduction in the quality of the work done here, but there will be an increased enthusiasm for this kind of work on the part of all problem solvers.

Kindly address Dr. Hassler as above.

[Note: Through an error the problems proposed in the April and May issues were numbered the same. The following are the solutions of those proposed in the May number.]

Algebra.

431. *Proposed by J. J. Ginsberg, Brooklyn, N. Y.*

Factor: $x^{10}+x^5+1$.

I. *Solution by R. M. Mathews, Riverside, California.*

By the factor theorem, if r be a root of $f(x)\equiv x^{10}+x^5+1=0$, then $x-r$ is a factor of $f(x)$. Here $f(x)$ is of the form y^2+y+1, the factors of which are $y-\omega$ and $y-\omega^2$ where ω is one of the complex cube roots of unity. So any factor of $x^5-\omega$ or of $x^5-\omega^2$ is a factor of $f(x)$. But $x=\omega^2$ reduces $x^5-\omega$ to zero as does $x=\omega$ for $x^5-\omega^2$. Thus $(x-\omega^2)(x-\omega)=x^2+x+1$ is a factor of $f(x)$, and $x^{10}+x^5+1=(x^2+x+1)(x^8-x^7+x^5-x^4+x^3-x+1)$. The factors of the second factor are made from the other complex roots of $x^5-\omega=0$ and $x^5-\omega=0$. These occur in conjugate pairs and the product of two will make *real* quadratic factors which, however, are not necessarily rational. Thus in the ordinary meaning of "factor," the product above is the solution of the problem. As a matter of interest, we note that the four real irrational quadratic factors are $x^2-\frac{1}{4}(1\pm\sqrt{5}\pm\sqrt{30+6\sqrt{5}})$ where the two ambiguous signs are independent.

II. *Solution by Norman Anning, Clayburn, B. C.*

$x^{10}+x^5+1$ has all the factors of $x^{15}-1$ which are not factors of x^5-1. $x^{15}-1$ is divisible by x^3-1, that is, by $x-1$ and x^2+x+1.

The first is a factor of x^5-1 but the second is not. It is therefore a factor of $x^{10}+x^5+1$.

$\therefore\ x^{10}+x^5+1 = (x^2+x+1)(x^8-x^7+x^5-x^4+x^3-x+1)$.

Note: Shungo Furni, Selma, Cal., obtained the following:

$$x^{10}+x^5+1=\left\{x+\sqrt[5]{\frac{1\pm\sqrt{-3}}{2}}\right\}\left\{x-\frac{\sqrt[5]{\frac{1\pm\sqrt{-3}}{2}}\left[1+\sqrt{5}\pm\sqrt{2\sqrt{5}-10}\right]}{4}\right\}$$

$$\left\{x-\frac{\sqrt[5]{\frac{1\pm\sqrt{-3}}{2}}\left[1-\sqrt{5}\pm\sqrt{-2\sqrt{5}-10}\right]}{4}\right\}$$

Geometry.

432. *Proposed by H. E. Trefethen, Waterville, Maine.*

Two unequal circles intersect in A and B. A straight line is drawn through A meeting the circles again in P and Q respectively.

Find the position of PAQ (a) when PA+AQ is greatest, (b) when $PA\cdot AQ$ is greatest.

I. *Solution by Norman Anning, Clayburn, B. C.*

Let C and D be the centres of the circles.

Draw CE and DF $\perp$ PQ and DG $\perp$ EC.

PQ = 2EF = 2GD.

GD is a chord of a circle on CD as diameter. Its maximum value is CD. PA+AQ has its greatest value, 2CD, when PQ is parallel to CD.

For all positions of PQ, the distance AB and the angles of ΔPBQ are constant.

$$PA = \frac{AB}{\sin APB}\sin PBA.$$

$$QA = \frac{AB}{\sin AQB}\sin QBA.$$

$$PA\cdot AQ = \frac{AB^2}{\sin APB \sin AQB}\cdot \sin PBA \sin QBA.$$

$$= \text{constant } x \sin PBA \sin QBA.$$

Now $2 \sin PBA \sin QBA = \cos(PBA-QBA)-\cos(PBA+QBA)$,

$= \cos(PBA-QBA)-\cos PBQ.$

Since $\cos PBQ$ is a constant, $\sin PBA \sin QBA$ is greatest when $\cos(PBA-QBA)$ is greatest; that is, when

$$PBA = QBA.$$

Therefore $PA\cdot AQ$ is greatest when BP and BQ make equal angles with BA.

II. *Solution by Elmer Schuyler, Brooklyn, N. Y.*

Let o_1 and o_2 be centres of the two circles and r_1, r_2 their respective radii.

(a) Let θ be the angle between PQ (in any position) and line o_1o_2, then $PA+AQ = 2\overline{o_1o_2}\cos\theta$, which is a maximum for $\theta = 0$.

Construction: Draw chord through A $\parallel$ to line of centres.

(b) Let θ be the angle of $\Delta\, o_1o_2A$ at point A and let ψ be the angle formed by PAQ with Ao_2, then $PA\cdot AQ = 4r_1r_2\cos\psi\cos(\theta+\psi)$ is to be a maximum.

This leads to $4r_1r_2\sin(\theta+2\psi) = 0$. The conditions of the problem require $\qquad \theta+2\psi = 0,$

from which $\qquad \psi = \pi-\theta-\psi.$

Construction: Draw PAQ so that it is the bisector of an exterior angle of $\Delta\, o_1Ao_2$ at point A.

III. *Solution by N. P. Pandya, Sojitra, Dt. Petlad, India.*

(a) Let C and D be the centres, and draw CF, DG, bisectors of PA, AQ respectively. Draw DE $\parallel$ QP.

Then PA+AQ = 2FA+2AG = 2FG = 2DE.

But as Δ CED is right, DE<CD.

$\therefore$ DE is greatest when E and C coincide, i. e., when DE is coincident with CD.

$\therefore$ PQ is greatest when it is $\parallel$ CD.

(b) $PA \cdot AQ = 2FA \cdot 2AG$

$$= 4CA \cos CAF \cdot DA \cos DAG$$

$$= 2CA \cdot DA\ [\cos(CAF+DAG)+\cos(CAF-DAG)]$$

This is greatest when $\cos(CAF-DAG)$ is greatest, i. e., when $\angle CAF = \angle DAG$, i. e., when PQ is $\perp$ to the bisector of $\angle CAD$.

433. *Proposed by H. E. Trefethen, Waterville, Maine.*

If D is the diameter of a circle, and d the distance between its centre and the intersection of perpendicular chords m and n, prove that $m^2+n^2 = 2D^2-4d^2$.

I. *Solution by Yeh Chi Sun, Peking, China.*

Let O be the centre; chords AB, CD are perpendicular and intersect at E.

Draw OF and OG $\perp$ to AB and CD.

Then, $$\overline{FB}^2 = \overline{OB}^2 - \overline{OF}^2 = r^2 - \overline{OF}^2.$$

$$\therefore \overline{AB}^2 = 4\overline{FB}^2 = 4r^2 - 4\overline{OF}^2.$$

Similarly, $$\overline{CD}^2 = 4\overline{CG}^2 = 4r^2 - 4\overline{OG}^2.$$

Adding, $$\overline{AB}^2+\overline{CD}^2 = 2.4r^2 - 4(\overline{OF}^2+\overline{OG}^2)$$

$$= 2D^2 - 4(\overline{EG}^2+\overline{OG}^2)$$

$$= 2D^2 - 4\overline{OE}^2$$

$$\therefore m^2+n^2 = 2D^2-4d^2.$$

II *Solution by R. M. Mathews, Riverside, California.*

Let perpendicular chords AB = m and CD = n intersect at F and let perpendiculars from centre O meet them at M and N respectively.

Then $\overline{OM}^2+\overline{ON}^2 = \overline{OF}^2 = d^2$.

Draw diameters AOX and COY, and chords BX and DY.

Then OM = ½BX and ON = ½DY, so

$\overline{BX}^2+\overline{DY}^2 = 4d^2$.

In inscribed right triangles ABX and CDY,

$$m^2 = \overline{AX}^2 - \overline{BX}^2.$$

$$n^2 = \overline{CY}^2 - \overline{DY}^2.$$

$$m^2+n^2 = \overline{AX}^2+\overline{CY}^2 - (\overline{BX}^2+\overline{DY}^2).$$

$$m^2+n^2 = 2D^2-4d^2.$$

434. *Proposed by H. C. McMillin, Kingman, Kansas.*

If perpendiculars are drawn from the orthocenter of the triangle ABC on the internal and external bisectors of the angle C, prove that their feet are collinear with the mid-point of AB.

I. *Solution by Elmer Schuyler, Brooklyn, N. Y.*

Let H be the orthocenter; D and E, the feet of the perpendiculars from A and B respectively upon BC and AC. Let M be the mid-point of AB, and L and N, the feet of the $\perp$s from H upon the internal and the external bisector of the angle C.

The circle on LN as diameter passes through points C, N, E, H, L and D. HLCN is a rectangle, hence the mid-point of HC (center of circle) lies on LN. Let V be the point of intersection of LN with DE. Since

$\angle$ACL $=$ $\angle$LCB by hypothesis, the arcs DL and LE are equal and diameter LN bisects chord DE (since it bisects one of its arcs). Finally, the mid-points of the three diagonals of a complete quadrilateral (here HDCE) are collinear, and consequently, since LN contains two of these mid-points, it must contain the third point, M.

II. *Solution by Norman Anning, Clayburn, B. C.*

Suppose $\angle A > \angle B$.

OM and ON are perpendiculars from the orthocenter, O, on the bisectors of $\angle$C.

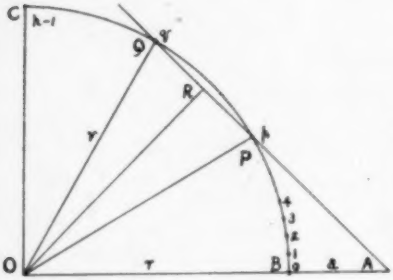
To prove that MN passes through the mid-point of AB.

Since OMCN is a rectangle, MN passes through the mid-point of OC. Call this point K. Produce KN to meet AB in L. Produce KO to meet AB in F.

To find FL from the right-angled ΔKFL.

$$
\begin{aligned}
KF &= KO+OF,\\
&= \tfrac{1}{2}CO+OA\cos B,\\
&= R\cos C+2R\cos A\cos B,\\
&= R\,[-\cos(A+B)+2\cos A\cos B\,]\\
&= R\cos\ (A-B).\\
\angle FKL &= 2\angle OCN,\\
&= 2\left(90^\circ-B-\frac{C}{2}\right)= A+B+C-2B-C\\
&= A-B.\\
FL &= KF\tan\angle FKL\\
&= R\cos(A-B)\tan(A-B),\\
&= R\sin(A-B).\\
AL &= AF+FL,\\
&= b\cos A+FL,\\
&= 2R\sin B\cos A+R\sin(A-B),\\
&= R\sin(A+B) = R\sin C = \frac{AB}{2}
\end{aligned}
$$

$\therefore$ MN passes through the mid-point of AB.



435. *Proposed by Nelson L. Roray, Metuchen, N. J.*

A curve on a railway, whose form is a circular quadrant, has telegraph posts at its extremities and at equal distances along the arc, the number of posts being n. A person in one of the extreme radii produced sees the pth and qth posts from the extremity nearest him (from which his distance is a) in a straight line. Find the radius of the curve.

I. *Solution by N. P. Pandya, Sojitra, Dt. Petlad, India.*

Let BAC be the quadrant, M the position of the man on AB produced, P and Q the pth and qth posts respectively, so that MPQ is a straight line. Let AX be $\perp$ PQ. Then AB $=$ AQ $= r$ and BM $= a$.

$\therefore$ $(r+a)\cos MAX = AX = r\cos QAX$.

$\therefore$ $r\,(\cos QAX-\cos MAX) = a\cos MAX$.

$$\therefore r = \frac{a\cos \mathrm{MAX}}{\cos \mathrm{QAX} - \cos \mathrm{MAX}} = \frac{a\cos \mathrm{MAX}}{2\sin\frac{\mathrm{MAP}}{2}\sin\frac{\mathrm{MAQ}}{2}}$$

$$= \frac{a\cos\frac{\pi(p+q-2)}{4(n-1)}}{2\sin\frac{(p-1)\pi}{4(n-1)}\sin\frac{(q-1,\pi}{4(n-1)}}$$

$$= \frac{a}{2}\left[\cot\frac{(p-1)\pi}{4(n-1)}\cot\frac{(q-1)\pi}{4(n-1)} - 1\right]$$

II. *Solution by Norman Anning, Clayburn, B. C.*

Radii to the n posts divide the quadrant into $(n-1)$ equal parts. Let $2\theta = \pi/2 \div (n-1)$.

Call the position of the observer A.

Call the center of the quadrant O.

Call the two posts, that are in line with A, P and Q.

To find r, the radius of the quadrant.

Draw OR $\perp$ PQ.

$$\begin{aligned}
\text{Angle POA} &= 2p\theta,\\
\text{Angle QOA} &= 2q\theta,\\
\text{Angle QOR} &= \angle\text{ROP} = (q-p)\theta,\\
\text{Angle ROA} &= (q+p)\theta.
\end{aligned}$$

$$\begin{aligned}
\text{OR} = \text{OQ}\cos\text{QOR} &= \text{OA}\cos\text{AOR},\\
= r\cos(q-p)\theta &= (r+a)\cos(q+p)\theta.\\
r[\cos(q-p)\theta - \cos(q+p)\theta] &= a\cos(q+p)\theta.\\
r\cdot 2\sin p\theta\sin q\theta &= a\cos(q+p)\theta.\\
r = \frac{a\cos(q+p)\theta}{2\sin p\theta\sin q\theta} \text{ where } \theta &= \frac{\pi}{4(n-1)}.
\end{aligned}$$

[NOTE: The difference in the answers obtained in the above solutions is due to a difference in interpreting what is meant by "*the pth and qth posts from the extremity nearest him.*"—EDITOR.]

CREDIT FOR SOLUTIONS.

431. Norman Anning, Herbert N. Carleton (2), Shungo Furni, J. J. Ginsberg, Edward F. Leimkuhler, R. M. Mathews, N. P. Pandya, Claude Schuder, Elmer Schuyler, Yeh Chi Sun. (11)

432. Norman Anning, N. P. Pandya, Elmer Schuyler. (3)

433. Norman Anning, Paul Baldwin, Edward F. Leimkuhler, L. E. A. Ling, R. M. Mathews, N. P. Pandya, Claude Schuder, Elmer Schuyler, Yeh Chi Sun. (9)

434. Norman Anning, N. P. Pandya, Elmer Schuyler, one incorrect solution. (4)

435. Norman Anning, N. P. Pandya, two incorrect solutions. (4)

Total number of solutions, 31.

PROBLEMS FOR SOLUTION.

Algebra.

446. *Proposed by George Raynor, Seattle, Washington.*

Solve:

$$x(x+y+z)-(y^2+z^2+yz) = a. \qquad (1)$$
$$y(x+y+z)-(z^2+x^2+zx) = b. \qquad (2)$$
$$z(x+y+z)-(x^2+xy+y^2) = c. \qquad (3)$$

Geometry.

447. *Proposed by Daniel Kreth, Wellman, Iowa.*

Given, in a right triangle, the difference between the base and the perpendicular, and also the difference between the hypotenuse and the base, to construct the triangle geometrically and determine its sides.

448. *Proposed by Elmer Schuyler, Brooklyn, N. Y.*

Given the sides of a triangle equal to a, b, c, respectively, to find the area of its pedal triangle in terms of these sides.

449. *Proposed by N. P. Pandya, Sojitra, Dt. Petlad, India.*

Construct a triangle, having given the perimeter, the vertical angle, and the ratio of the sides containing that angle.

Trigonometry.

450. *Proposed by O. N. Horner, Peru, Indiana.*

A crossed belt is carried on two pulleys of the same size. If the belt is 10 feet long and half of it is in contact with the surface of the pulleys, what is the radius of the pulleys?

SCIENCE QUESTIONS.

By Franklin T. Jones,
University School, Cleveland, Ohio.

Readers of School Science and Mathematics *are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.*

Questions and Problems for Solution.

193. *Proposed from Bloomington, Ill., in an unsigned letter.*

I would like to have some physics teacher answer this question asked me by a boy in my physics class:

Induced E. M. F. is proportional to the rate of change in the magnetic flux. In A. C. transformers this change is caused by the alternations of the current and so the rate of change seems to be determined by the frequency of the alternations, yet the ratio of the secondary E. M. F. to the primary is given as the ratio of the number of turns in the secondary to the number in the primary regardless of the number of cycles per second.

194: *From an entrance examination of Columbia University.*

A man weighing 150 pounds carries a load of 70 pounds up an incline of one in ten. If he walks at the rate of one thousand feet per minute, what horse power is he exerting? Answer to be in foot pounds per second.

[Is the answer reasonable? Should problems with unreasonable answers be given, especially on examinations?—Editor.]

195. *Suggested by an Associated Press dispatch, dated St. Louis, Mo., May 2, 1915.*

At Tipton hailstones were found which measured 8½ inches in diameter and weighed half a pound. Hailstones fell as large as baseballs.

[How much would such hailstones weigh?—Editor.]

Please answer questions numbered 196 and 197 in the following lists:

YALE COLLEGE—SHEFFIELD SCIENTIFIC SCHOOL—ENTRANCE EXAMINATION IN PHYSICS.

June, 1915—Friday, 2:00-4:30.

1. Which has the greater momentum, a 100-pound cannon ball moving at the rate of 1,100 feet per second or a 15-ton car moving at the rate of 15 miles per hour? Which has the greater kinetic energy? Show by calculation how you derive your conclusions.

2. If it is found possible, by a wheel and axle, to raise a weight of 500 pounds by applying a force of 70 pounds, when the diameter of the wheel is 4 feet and that of the axle is 6 inches; calculate (a) the frictional force, (b) the efficiency and (c) the mechanical advantage of the machine.

196. A pneumatic tire is blown up to a pressure of 75 pounds per square inch. In the pump employed, the piston area is 3 square inches and its travel is 15 inches. At what point in the piston travel will the tire valve open on the last stroke of the pump? What force must be exerted on the piston at that moment? Explain the heating of the rubber tube connecting the pump and tire in this process.

4. Cite some examples of the conversion of heat into work, and of work into heat. State the exact relation between the work and the heat which has been determined by experiment. How was this found? By whom? When?

5. What determines the loudness of a sound? Explain the effect of increasing the tension on a violin string. What rôle is played by the bridge; and what by the body of the violin?

6. Discuss the essential features of construction and the principle of a voltmeter. State what instruments you would choose, and show by a diagram how you would connect them, to measure the power consumed by an incandescent light.

7. Describe the construction of a storage cell. Discuss the principle of the cell, showing by a diagram the connections for charging and the changes which are taking place during the charging.

8. What is a spectrum? How may it be formed? Describe the solar spectrum and mention some practical application of spectrum analysis.

YALE COLLEGE—SHEFFIELD SCIENTIFIC SCHOOL—ENTRANCE EXAMINATION IN CHEMISTRY.

June, 1915—Friday, 2:00-4:30.

1. Give the chemical formulas of the following compounds: ammonium nitrate; silicon fluoride; potassium chlorate; calcium fluoride; lead chromate; mercuric sulphide; aluminium phosphate; stannic chloride; ferric sulphate; hydrogen dioxide.

2. Name three important constituents of air. How would you prepare these substances by chemical means? Illustrate by equations.

3. How would you prepare (a) hydrogen sodium carbonate from normal sodium carbonate? (b) normal sodium carbonate from hydrogen sodium carbonate? (c) normal sodium carbonate from sodium chloride? (d) normal sodium carbonate from sodium hydroxide? Equations.

4. Give brief descriptions of the following technical processes; preparation of (a) nitric acid; (b) iron from an iron ore; (c) calcium oxide from limestone. Write the equations for the reactions involved.

5. (a) Calculate the percentage of each element in sodium sulphate. (b) How much sodium chloride would be required to form 10 grams of hydrogen sodium sulphate? $NaCl + H_2SO_4 = NaHSO_4 + HCl$.

6. How can sodium chloride be distinguished from sodium bromide? Give equations, where possible, for the reactions.

197. Assume that a sample of sulphuric acid has the specific gravity of 1.8. and contains 98 per cent H_2SO_4. How many grams of the compound H_2SO_4 are contained in 25 c. c.?

8. Write an equation showing the combustion of methane (CH_4) in oxygen. If a gram molecular weight of methane is used (16 grams), give the weights in grams of all the other substances taking part, and the volumes of all gases 0°C. and 1 atmosphere pressure.

(*Atomic weights:* Na = 23; Cl = 35.5; H = 1; S = 32; O = 16; C = 12.)

Solutions and Answers.

184. *From a Regent's Examination.*

The pressure in a city water main is 40 pounds per square inch. The diameter of the plunger of a hydraulic elevator is 12 inches. Loss by friction is 33⅓ per cent. How heavy a load can the elevator lift?

Solution by Robt. W. Boreman, Parkersburg, W. Va.

Area of circle $= \pi r^2 = 3.1416 \times 6^2 = 113.0976$ sq. in.

$40 \times 113.0976 = 4523.904$ lbs. per square inch.

33⅓% of 4,523.904 = 1,507.968.

4,523.904—1,507.968 = 3,015.936 lbs. of effective pressure that can be applied in lifting the elevator.

185. *From a Regent's Examination.*

If the specific gravity of ice is .92 and the specific gravity of sea water is 1.027, what is the greatest weight that a cubic yard of ice floating in sea water will support?

Solution by R. W. Boreman.

1 cu. ft. of the sea water weighs $62.5 \times 1.027 = 64.187$ lbs.

$64.187 \times 27 = 1,733.049$ lbs., weight of 1 cu. yard of sea water.

$.92 \times 62.5 \times 27 = 1,552.50$ lbs., weight of cu. yard of ice.

1,733.049—1,552.50 = 180.55 lbs. that the ice will support.

ARTICLES IN CURRENT PERIODICALS.

American Forestry for September; *Washington, D. C.; $3.00 per year, 25 cents a copy:* "The Longleaf Pine—Identification and Characteristics" (with two illustrations); "Commercial Uses of Longleaf Pine" (with sixteen illustrations), P. L. Buttrick; "Forests in the War Zone" (with two illustrations); "The Bird Department" (with two illustrations), A. A. Allen; "Aviator to Detect Forest Fires" (with two illustrations); "The Ornamental Evergreens" (with seven illustrations), Warren H. Miller; "American Trees in German Forests" (with seven illustrations), J. S. Illick; "Tree Planting Along the Lincoln Highway," Grace Roper Nevitt; "Ornamental and Shade Trees—Tree Pruning" (with three illustrations), J. J. Levison.

American Mathematical Monthly for September; *5548 Kenwood Ave., Chicago; $2.00 per year:* "Hisory of Zeno's Arguments on Motion—VIII," Florian Cajori; "On Napier's Fundamental Theorem Relating to Right Spherical Triangles," Robert Moritz; "An Interpolation Formula for Poisson's Exponential Binomial Limit," E. C. Molina; "A Simple Solution of the Diophantine Equation," J. W. Nicholson; "Problems and Solutions," B. F. Finkel and R. P. Baker; "Questions and Discussions," U. G. Mitchell.

American Naturalist for March; *Garrison, N. Y.; $4.00 per year; 40 cents a copy:* "A Study of Asymmetry, as Developed in the Genera and Families of Recent Crinoids," Austin H. Clark; "Inheritance of Habit in the Common Bean," John B. Norton; "On the Modification of Characters by Crossing," Dr. R. Ruggles Gates.

Condor for July-August; *Hollywood, California; $1.50 per year, 30 cents a copy;* "Nesting of the Bohemian Waxwing in Northern British Columbia" (with two photos), Ernest M. Anderson; "Notes on Some Birds of

Spring Canyon, Colorado," W. L. Burnett; "Woodpeckers of the Arizona Lowlands" (with ten photos), M. French Gilman; "Notes from the San Bernardino Mountains," Adriaan van Rossem and Wright M. Pierce.

Journal of Geography for September; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "The Money Value of Rainfall in Selected Crop Areas of the United States," E. J. Cragoe; "The Rio Theodoro, Colonel Roosevelt's New River," J. Paul Goode; "The Site of Cincinnati," N. M. Fenneman; "Geography in the St. Louis Public Schools," W. J. Stevens; "Conditions in China."

L'Enseignement Mathématique for March; *Stechert & Co., West 25th St., New York; 15 francs per year, 2 francs a copy:* "Sur les bases de l'analyse vectorielle," E. Dumont; "Les nombres premiers, décomposition d'un nombre en ses facteurs premiers," H. E. Hansen; "Sur l'enseignement des mathématiques," G. Fontené; "La trigomométrie dans ses rapports avec la géométrie," A. Streit.

Mathematical Gazette for May; *G. Bell & Sons, Portugal St., Kingsway, London; 6 nos., 9s. per year, 2 s., 6 d. a copy:* "Notes on the Teaching of Arithmetic," Mrs. F. G. Shinn; "Notes on the Board of Education Circular, No. 851," Miss M. J. Parker; "The Dissection of Rectilineal Figures," W. H. Macaulay; "The Discovery of Logarithms by Napier," H. S. Carslaw; "Mathematical Notes."

Scientific Monthly for October; *Garrison, N. Y.; $3.00 per year, 30 cents a copy:* "The Evolution of the Stars and the Formation of the Earth," Dr. William Wallace Campbell; "The History of Fiji," Dr. Alfred Goldsborough Mayer; "An Interpretation of Slavophilism," Arthur D. Rees; "Physical Training as Mental Training," Dr. J. H. McBride; "Edward Jenner and Vaccination," D. F. Harris; "The Value of Industrial Research," W. A. Hamor; "A Few Classic Unknowns in Mathematics," Professor G. A. Miller; "The Aboriginal Rock-stencillings of New South Wales," Dr. Chas. B. Davenport.

School World for August; *Macmillan Company, London, Eng.; 7s. 6d. per year, 6 pence a copy:* "The Teaching of Modern European History," F. J. C. Hearnshaw; "Geography Albums," Miss Gundred H. Savory; "The Junior Secondary School," Miss E. M. Leahy, M. A.; "'Free Places' in Secondary Schools," Miss L. A. Lowe; "The Spirit of Science," R. A. Gregory; "Secondary Education in England."

Unterrichtsblätter für Mathematik und Naturwissenschaften, Nr. 2; *Otto Salle, Elssholzerstr, 15, Berlin W. 57, Germany; M. 4 per year, 60 Pf. a copy:* "Ist die Zentralperspektive der Parallelperspektive bei der Darstellung des Körper in stereometrischen Unterricht in Untersekunda vorzuziehen? I," Dr. F. Thaer; "Spezialistentum und Schulunterricht," Prof. Dr. R. V. Hanstein; "Verhandlung des Kommission für die Formelzeichen des AEF," "Zur zeichnerischen Losüng der Heronischon Brunnenanfgaben," A. Th. Diestler.

Nr. 3: "Ist die Zentralperspektive des Parallel-perspektive bei der Darstellung der Körper im stereometrischen Unterricht in Untersekunda vorzuziehen? II," Dr. F. Thaer; "Versuche zum Wechselstrom," Dr. E. Magin; "Zur Geometrie am Dreieck," Prof. Jos. Moser; "Zum kinetischen Bewer's des aussenwinkelsatzes von G. Grimm," Oberlehrer Dr. L. Wulff.

Zeitschrift für den Physikolischen und Chemischen Unterricht, for July; *in Berlin, W. 9, Link Sts. 23-24; 6 No. $2.88 M. 12 per year:* "Krieg und physikalischer Unterricht," P. Spies; "Aufgaben zur Himmelskunde," P. Luckey; "Herstellung von Fernrohr und Mikroskop im Handfertigkeitsunterricht," P. Nickel; "Unipolare Rotation und Induktion," J. Kollert; "Das Mariotte-Gay-Lussacsche Gesetz (Zustandsgleichung der Gase) in den physikalischen Übungen," Th. Backhaus; "Bewegungserscheinung beim Kondensieren von Dampf in kaltem Wasser," H. Rebenstorff; "Eine einfache Messung im magnetischen Feld," E. Magin; "Ein Reversions-Nitrometer," O. Lubarsch; "O. Praetorius," Versuche mit einfachen Mitteln.

THE ANNUAL 1915 MEETING OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The fifteenth annual meeting of the Central Association of Science and Mathematics Teachers will be held at Chicago in the new building of the Harrison Technical High School, November 26th and 27th. Plans for the meeting provide programs for the general sessions and section meetings, which include addresses, papers, and discussions on some of the most important topics now under consideration in secondary-school work.

At the general session on Friday morning, November 26th, addresses will be given by Earle R. Hedrick, professor of mathematics, University of Missouri, Cyril G. Hopkins, professor of agronomy, University of Illinois, and Edward H. Steiner, sociologist, Grinnell College, Iowa. The remarkable development of the high school in recent years and the new demands made upon it have given rise to questions of reorganization and administration, which affect the teacher as well as the pupil. The speakers at this sesssin are peculiarly well fitted to deal with these questions, and teachers of science or mathematics in the territory of the association cannot afford to miss this opportunity of broadening their outlook on the practical problems of readjustment and getting suggestions of real value to aid in solving these problems in their own school.

On Friday evening, William B. Ittner of St. Louis, architect of the Board of Education of St. Louis, and one of the foremost architects of school buildings in the country, will give a most interesting and valuable address on school architecture, Mr. William R. Moss, Chicago Association of Commerce, will give an address from the viewpoint of a business man as to what business demands of science and mathematics teaching, and Mr. A. A. Upham of the Whitewater Normal School, Wisconsin, will speak from a school man's point of view concerning the business management of our school systems.

The programs of the section meetings, Agriculture, Biology, Chemistry, Earth Science, Home Economics, and Mathematics, include papers by many of the ablest and most prominent teachers of the country. Committees appointed in the various sections at the last annual meeting have been at work during the year and will report at this meeting. It is expected that ample time will be allowed in each section for general discussion. The program will be sent out early in November, and members are urged to come to the meeting prepared to take part in the discussion of papers.

All teachers of science and mathematics interested in making their work of greater value to pupils and to the community who have not availed themselves of the benefits of this Association, are cordially invited to attend this meeting and enroll themselves as members. Not the least pleasure and profit of attending the annual meetings of this Association is the opportunity it gives of renewing old friendships and forming new ones. The mutual exchange of ideas and experiences will furnish inspiration for the work of another year.

For programs and additional information, write the Secretary, Mr. A. W. Cavanaugh, Lewis Institute, Chicago.

PROPOSED CHANGES IN THE CONSTITUTION OF THE CENTRAL ASSOCIATION.

The Committee on Revision of the Constitution of the Central Association of Science and Mathematics Teachers proposes the following changes. Since the changes are all additions, the parts of the Constitution affected are quoted in revised form, with the additional words italicized. The designation "Assistant Secretary" is changed to "Corresponding Secretary."

Article IV, first sentence. This Association shall be divided into sections as follows: *Agriculture,* Biology, Chemistry, Earth Science, *Home Economics,* Mathematics and Astronomy, and Physics.

Article VI, Sec. 1. The officers of the Association shall be a President, a Vice-President, a *Recording* Secretary, a *Corresponding* Secretary, a Treasurer, and an Assistant Treasurer.

Article VI, Sec. 4, sentences 3 and 4. The President, Vice-President, *Corresponding* Secretary, and Assistant Treasurer each shall be elected for a term of one year. The *Recording* Secretary shall be elected for a term of two years.

W. L. Eikenberry,
C. H. Smith,
Minna C. Denton.

EASTERN ASSOCIATION OF PHYSICS TEACHERS.

The 70th regular meeting of this very wide-awake Association was held Saturday, March 20th, in the Medford High School, Medford, Mass. The regular meeting was preceded by a short session of the Executive Committee, after which the meeting as a whole opened with a business session, at which the members listened to reports from the various standing committees. The first report was that of the Secretary, and this was followed by the Treasurer's report which showed a very substantial amount in the treasury. Mr. Cowan, as Chairman of the Committee on New Apparatus, reported some interesting new apparatus recently put out by the Knowt Apparatus Co. Mr. Brayton, physics instructor in the Medford High School, then gave a short account of the electrical equipment in the laboratory of this school. The Committee on New Books, of which Clarence Boylston is Chairman, presented its report, and this time it was on two books in first year science, one by Dr. Hessler of the Jas. Milliken University and the other by Dr. Snyder of the Hollywood High School, Los Angeles. The Committee on Current Events had been busy since the last meeting and had collected several interesting bits of information which were at this time presented to the meeting. This was followed by the report of the Committee on Magazine Literature It gave a summary of the leading articles appearing about physics, which have been published during the past year. Several new names were elected to membership, and the following officers were elected for the year 1915-16:

President—Clarence M. Hall, Springfield, Mass.
Vice-President—Frederick E. Sears, St. Paul's School.
Secretary—Alfred M. Butler, Boston.
Treasurer—Percy F. Brayton, Medford, Mass.

Mr. N. Henry Black of the Roxbury Latin School then read an appreciation of Prof. Ernst Grimsehl, a splendid German physics teacher who fell in battle while defending his country. Resolutions concerning this man were presented and unanimously adopted. These were printed in the June issue of this Journal.

The real subject of the meeting was then taken up, which was a symposium on the subject, "What Should Be the Aim in High School Physics Teaching?" This was discussed in a very able way by several people. This was taken up from the religious point of view by Dr. Chas. F. Dole, President of the Twentieth Century Club, Boston. He was followed by Mr. Henry Abrams, Secretary of the Central Labor Union of Boston, who spoke from the point of view of the laboring man. At the conclusion of this talk the meeting adjourned for luncheon, which was served by the domestic science class of the Medford High School.

In the afternoon session the discussion was continued by Dr. Hermon Bumpus, President of Tufts College, who spoke from the college man's point of view. Following this, Dean Gardner Anthony of Tufts presented a paper from the engineer's point of view, after which President Williston of Wentworth Institute summed up the addresses of the other speakers in a very interesting and instructive way.

At the conclusion of this talk the meeting adjourned, everyone present expressing himself in such a way as to show that the session had been one of the most helpful in the history of the Association.

THE NATIONAL ASSOCIATION OF TEACHERS' AGENCIES.

The purpose of the National Association of Teachers' Agencies is to make the work of the agencies of the greatest possible value to the educational institutions and to the teachers who use their service. The work of the agencies is purely professional and nothing which is contrary to the written or unwritten law of the profession of education will be tolerated by the Association on the part of any member.

Perhaps no more important duty is performed by an educator in the capacity of an executive officer than the selection of his teachers. It is this function which is delegated to a greater or less degree to the teachers' agency. How well they have met the exacting demands of this work is evidenced by the wonderful growth of the teachers' agency business and by the status of the business at the present time. The fact that the National Association of Teachers' Agencies is affiliated with the N. E. A. and was given a place on the official program at the Cincinnati meeting last February (Department of Superintendence) is evidence of the educational standing of our organization.

The keynote of the Association is to standardize the agency business and to make the agency work professional instead of purely commercial. To the extent our work becomes recognized as being educational, to that same extent will the business become more profitable and successful.

We intend that membership in our National Association shall mean dependability and reliability. Any teachers' agency which is a member will be, in general, worthy of confidence. The officers of the Association will exercise all possible care in the admission of members. Every member will print on his letterheads, "Member National Association Teachers' Agencies."

The time has gone by when anybody can print a few letterheads and go unchallenged before the educational public as a teachers' agency.

The members of our Association have become acquainted and have shown a fine spirit of co-operation. This has resulted to the good of the service in many ways helpful to schools and teachers. Better systems of keeping records, constantly decreasing tendency to loose methods, greater directness of work—and other things, some little, some important, which go to make efficiency—have resulted. The use of lawyers is regarded as unnecessary in settling differences between agencies and teachers. When two agencies have each a claim for a commission from the same teacher, such claims are now adjusted by a committee. A uniform contract is another matter which is before the Executive Committee.

When you think that our National Association is only in its second year, the results already accomplished seem noteworthy and augur well for the future. Verily, in union there is strength! B. F. Clark,

Secretary.

MEETING OF THE ASSOCIATION OF MATHEMATICS TEACHERS OF NEW JERSEY.

The second regular meeting of this Association was held Saturday, May 1st, at the Trenton Normal School. The morning session opened by an address of welcome by Principal Jas. M. Green, and was responded to by Prof. Richard Morris. The Council of the Association then presented its report. This was followed by an address on the "Affine Geometry," by Prof. Oswald Veblen, of Princeton University. The President, Prof. Richard Morris, then presented his address on the "Auxiliary Angle." This address was followed by a paper on "Mathematics and Efficiency," by Dr. Fletcher Durrell of the Lawrenceville School. "First Year Mathematics for a Technical High School" was the subject of a paper given by Mr. Arthur W. Belcher of the East Side High School, Newark. At the close of this paper the meeting adjourned for luncheon, which was served in the normal school building. At this very interesting time the members of the Association were enabled to get more intimately acquainted with each other in discussing the various problems which they meet in their particular lines of work.

At the afternoon session the first paper was read by Prof. Chas. O. Gunther of Stevens Institute on "Trigonometry for the College Student." After a discussion, Mr. J. W. Colliton of the Trenton High School read a paper on the "Study Conference Plan in Mathematics." Mr. Harrison E. Webb of the Central High School Newark, then read an interesting paper on the "Geometric Definition of the Trigometric Functions." Mr. Webb also presented a second paper on the "Outline of a Course in Advanced Commercial Algebra."

It was agreed by all present that the meeting had been interesting and profitable, and that these meetings should be continued at regular intervals in the future.

A SUGGESTION FOR LABORATORY NOTEBOOKS.

By N. M. Grier,

Central High School, St. Louis, Mo.

It can hardly be doubted that careful training in the preparation of laboratory notebooks is a valuable potentiality to the student in later life. No small part of this desirable routine is the careful labeling of diagrams of apparatus used and drawings made in the laboratory. But what is frequently an excellent representation of the object at hand is often spoiled as regards its general appearance by the style of printing used in the labels. Freehand lettering, too, is an art which will probably stand most students good after the period of high school notebooks in science.

The writer, in his laboratory work at the Central High School, has found the system of lettering taught in elementary courses of mechanical drawing of great advantage here. Consisting, as it does, of modifications of the letter O and a straight line, he has observed that most students, other than those in the mechanical drawing courses, acquire an ability in such a type of lettering in a relatively short time. It can easily be taught in a synthetic manner, or by having the students merely copy a chart of the letters and numerals used.

While the writer is unable to claim any originality for this procedure, he believes that its practicability justifies greater usage than he has been able to observe. A fuller discussion of this method of lettering may be found in Reinhardt's and Jacoby's texts of *Elementary Mechanical Drawing* and Phillip's *Chapter on Lettering*.

PERSONALS.

Professor John N. Swan has resigned his position in Monmouth College and accepted the head professorship of chemistry in the University of Mississippi at University.

Mr. Carl Garlough, for a number of years superintendent of schools at Jerseyville, Ill., has accepted a place in the mathematics department of Wheaton College.

Dr. Karl Eugen Guthe, professor of physics in the University of Michiigan and dean of the Graduate School, died on September 11th, following a surgical operation. He was born in Hanover, Germany.

Dr. T. C. Hebb, professor of physics at the Northern State Normal School, Marquette, Michigan, has been granted his sabbatical year and will devote it to study at Columbia University.

Mr. C. W. Botkin who, for seven years, taught chemistry in Ottumwa, Iowa, High School, has been made head of the chemistry department in Wheaton College.

Professor F. Cajori, a frequent contributor and adviser of this Journal, has resumed work at Colorado College after spending the past year abroad. The greater part of the year he spent in the libraries of Oxford, Cambridge and London, where he was engaged in researches on the history of certain branches of mathematics in Great Britain during the seventeenth and eighteenth centuries.

Dr. Ivey F. Lewis, of the University of Missouri, has become professor of biology and head of the school of biology at the University of Virginia.

R. H. Bogue, formerly at the Massachusetts Agricultural College, has been appointed assistant professor of chemistry and geology in the Montana State College.

Dr. Paul H. Dike has been appointed professor of physics in Robert College, Constantinople, to succeed Professor Manning, who died last year. He sailed on the Greek line to Piraeus on September 15th, together with a number of the members of the faculty of Robert College. The college is to open in spite of the war.

WILD FLOWERS.

Few people seem to appreciate the fact our wild flowers, distributed all through the country and especially within a radius of twenty-five or thirty miles of large centers of population, need to be protected by stringent laws just as much as our birds, if they are to be perpetuated among us. Many of these flowers are now destroyed and gotten rid of by landowners who consider them no more than pestiferous weeds. Likewise our good friends from the city, in making excursions into the country from early spring until late fall, seem to take delight in digging up and picking and destroying in one way or another these flowers in such a way that they will not reproduce themselves the following year. For instance, in the great state of Illinois, there are now but very few areas which beautify the state, since man began to turn the sod. A very small quota of the original flowers of

the state now remain. It would seem that there ought to be set apart a large section of land as a place in which all plants indigenous to the state might grow and develop in their natural environment. If this is not done, within a few years many of our wild plants will become extinct. The writer is here advocating again that which he has been agitating for several years, that the Board of Education of every large city should purchase as large an area of land within easy reach of the city, as is possible, for the purpose of developing a near-to-Nature park, in which the various botanical, zo-ological, and physiographical features may be preserved for all time. This would at the same time provide a place where classes studying the subjects indicated above might be taken at the right seasons of the year, to study in an environment which is absolutely natural, the contents of the park, thus getting in touch with the way in which plants and animals grow and develop when left entirely to themselves. It would seem that Nature-study teachers and all people interested in these phases of education, should use their best endeavors to preserve sections of their state in its natural condition and beauty.

CLASS ROOM STORIES.

In a physics class, the instructor was endeavoring to make clear the difference between an ohm and a volt, and was trying to impress upon the pupils' minds the fact that they must not under any circumstances call the resistance in a wire a certain number of volts, or say that the electromotive force is so many ohms. He said, to illustrate, that it would be just as ridiculous to do this as to say that the distance between Chicago and Detroit is 284 girls. He had no more than gotten the word "girls" out of his mouth, when a young man in the front row asked the question, "Is not a miss as good as a mile?"

Some time ago in a certain physics class, the instructor asked a young lady to explain the process of electrotyping. She went through with the explanation very nicely until she came to the place where something must be said about making the surface of the wax impression a conductor. The remark she then made was, "The impression is then sprinkled over with powdered lumbago!"

Recently an extraordinarily large boy presented himself for registration at the Hyde Park High School, Chicago. He presented some credentials from the high school in another city. On being asked by the registrar what subjects he intended to take, he replied that there was one subject that his father told him not to take, and that was the subject of physics, "because father says he does not desire me to know anything about drugs."

Recently in the Hyde Park High School, Chicago, the person who has to deal with the greater portion of the disciplinary work of the school had occasion to hold a private conference with a young fellow whose parents are rather wealthy. The teacher was morally certain that the young man had been matching pennies. In the conversation the young man was soon shedding tears to a considerable extent, and the teacher thought it a good opportunity to mention that he was sorry the boy had been gambling in this way. The young man replied that he had not been matching pennies. The instructor insisted that he was positive that he had, and had evidence to prove it, whereupon the young man replied, "No, I was not matching pennies, but I was matching nickels."

AN ADJUSTABLE SUNDIAL.

By J. F. Morse,

Instructor in Astronomy, Hyde Park High School, Chicago.

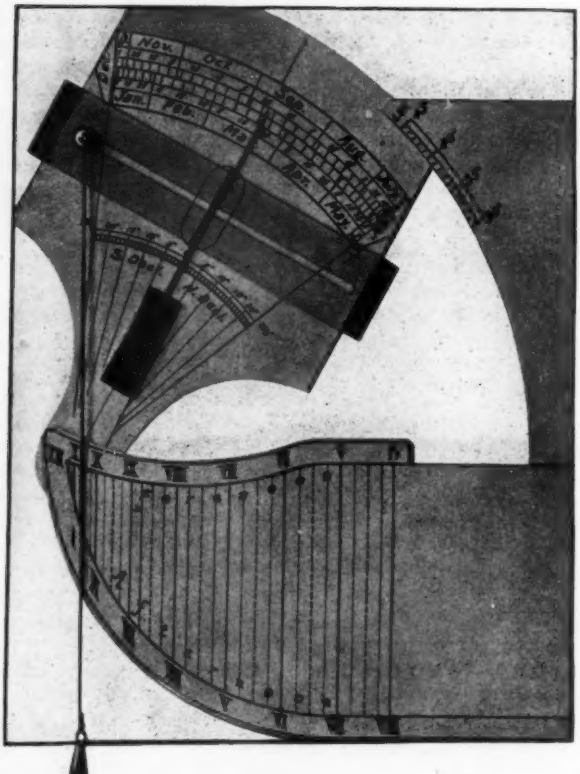
The universal sundial in the illustration is the invention of Mr. Leinert of New York City.

It is adjustable for latitudes 30°-45° N.

The dial is of the type which is moved in a vertical plane until the sun light shining through a slit falls on a "sun-line," as shown in upper part of drawing. A plumb-line then shows the hour of the day.

The point from which the plumb-line is suspended must be movable in a way to fit the latitude and the date. Mr. Leinert accomplishes this as follows:

The plumb-line is suspended from a button that glides in a slot in a piece of celluloid, which, in turn, slides over a sector carrying the date-scale. The sector is adjusted for a given latitude by bringing its center



line opposite the latitude. The celluloid is properly placed on the sector by bringing its center directly over a fixed vertical line visible through a central radial slit in the sector. The button is then brought to the proper place in the celluloid slot by setting a pointer that is pivoted to center of sector at the desired date. When the button has been thus adjusted a bead that slides on the plumb-line is brought to the 12 o'clock (noon) mark of dial. Then if the dial is held so that the sunlight falls through the gnomon slit on the sun-line, and the plumb-line hangs freely, just touching the face of the dial, the bead will indicate the hour of the day.

The sector also carries a declination scale, so placed that the pointer indicates the sun's declination on the date to which it points.

The time of sunrise and sunset at a given latitude and date can be determined by holding the dial, when properly adjusted, so that the sun-line is horizontal. The plumb-line will then fall parallel with the hour lines and will indicate sunrise and sunset times.

By means of an equation-of-time graph on back of dial, the apparent solar time given by dial can be converted into mean solar time, and then by proper allowance for observer's direction and distance in degrees from the nearest standard meridian, the mean local time can be changed into clock time.

BOOKS RECEIVED.

Practical Mathematics for Advanced Technical Students by H. Leslie Mann, Woolwich Polytechnic. Pages xiii+487. 14.5x22.5 cm. Cloth 1915. $2.10 net. Longmans, Green & Co., New York.

Handbook of Physiology, by W. D. Halliburton, King's College, London. Pages xix+924. 16x22.5 cm. Cloth. 1915. $3.00 net. P. Blakiston's Son & Co., Philadelphia.

Experimental Plant Physiology, by Lucy E. Cox, Graystoke Place Training College, London. Pages vii+111. 13x19 cm. Cloth. 1915. 60 cents net. Longmans, Green & Co., New York.

Practical Applied Mathematics, by Joseph W. L. Hale, Pennsylvania State College. Pages xi+206. 12x18 cm. Cloth. 1915. $1.00 net. McGraw-Hill Book Co., New York.

Laboratory Exercises in Chemistry, by William McPherson and William E. Henderson, Ohio State University, Pages xi+128. 13.5x19.5 cm. Cloth. 1915. 40 cents. Ginn & Company, Boston.

A Course in Invertebrate Zo-ology, by Henry S. Pratt, Haverford College. Pages xii+228. 15x21 cm. Cloth. 1915. $1.25. Ginn & Company, Boston.

School Arithmetic, Intermediate Book, by Florian Cajori, Colorado College. Pages ix+299. 13x19 cm. Cloth. 1915. 40 cents. The Macmillan Company, New York.

Quantitative Chemical Analysis, by Nicholas Knight, Cornell College. Pages vii+153. 13.5x19. Cloth. 1915. A. S. Barnes Company, Chicago.

A First School Calculus, by R. Wyke Bayliss, Whitgift School. Pages xii+288. 13x19 cm. Cloth. 1915. $1.20. Longmans, Green & Co., New York.

Plane Geometry, by Claude I. Palmer, Armour Institute, Chicago, and Daniel P. Taylor High School, Oak Park, Ill. Pages v+277. 13.5x20 cm. Cloth. 1915. Scott, Foresman & Co., Chicago.

Elementary and Applied Chemistry, with manual, by Frederick C. Irwin, Byron J. Rivett and Orrell Tatlock, Detroit High Schools. Pages xv+495. 14x19.5 cm. Cloth. 1915. Row, Peterson & Co., Chicago.

First Course in General Science, by Clem A. Pease, High School, Hartford, Conn. 315 pages. 13.5x19 cm. Cloth. 1915. $1.20 Charles E. Merrill Company, New York.

Laboratory Manual of Horticulture, by George W. Hood, University of Nebraska. Pages vii+234. 15.5x24 cm. Cloth. 1915. $1.00. Ginn & Company, Boston.

Mortality Laws and Statistics, by Robert Henderson, Actuary Equitable Assurance Company. Pages v+111. 15x23.5 cm. Cloth. 1915. $1.25. John Wiley & Sons, New York.

The Practical Conduct of Play, by Henry S. Curtis, Supervisor of Playgrounds, District of Columbia. Pages ix+330. 13.5x19.5 cm. Cloth. 1915. $2.00. The Macmillan Company, New York.

Outlines of Sociology, by Frank W. Blackmar, University of Kansas, and John S. Gillin, University of Wisconsin. Pages ix+586. 14x20.5 cm. Cloth. 1915. $2.00. The Macmillan Company, New York.

The Elements of Physical Chemistry, by Harry C. Jones, Johns Hopkins University. Pages xiv+672. 15.5x22.5. Cloth. 1915. $4.00. The Macmillan Company, New York.

Practical Lessons in Agriculture, by Lester S. Ivins, State Supervisor, Ohio, and Frederick A. Merrill, State Normal School, Athens, Ga. Pages vi+223. 19.5x24 cm. Cloth. 1915.

The American Book Co., Chicago.

School Algebra, by H. L. Rietz, A. R. Crathorne, University of Illinois, and E. H. Taylor, Normal School, Charleston, Ill. Pages xiii+271. 13x19.5 cm. Cloth. 1915. $1.00. Henry Holt & Co., New York.

Plane Geometry, by John W. Young, Dartmouth College, and Albert J. Schwartz, McKinley High School, St. Louis. Pages x+223. 12.5x19 cm. Cloth. 1915. $1.00. Henry Holt & Company, New York.

A Handbook of Elementary Sewing, by Etta Proctor Flagg, Los Angeles City Schools. Pages ix+72. 13x19.5 cm. Cloth. 1915. 50 cents. Little, Brown & Company, Boston.

Everyday Arithmetic, by John B. Gifford. Pages x+194. 14x19 cm. Cloth. 1915. 35 cents. Little, Brown & Company, Boston.

The Yearbook of Wireless Telegraphy and Telephony. Pages xcvi+800. 14.5x21.5. Cloth. 1915. The Marconi Pub. Corporation, New York City.

Luft, Wasser, Licht und Wörme, by R. Blackmann. Verlag von B. G. Teubner in Leipzig.

Die Polarforschung, by K. Hoffert. Verlag von B. G. Teubner in Leipzig.

Die Urtiere, by R. Goldschmidt. Verlag von B. G. Teubner in Leipzig.

Das Skelett, by K. V. Bardeleben. Verlag von B. G. Teubner in Leipzig.

Die Eingeweide, by K. V. Bardeleben. Verlag von B. G. Teubner in Leipzig.

Das Muskel und Gefass-Susten, by K. V. Bardeleben. Verlag von B. G. Teubner in Leipzig.

Die Beziehengen des Tiere und Pflanzen zueinander I., by K. Kroepelin. Verlag von B. G. Teubner in Leipzig.

Die Beziehengen des Tiere und Pflanzen zueinander I., by K. Kropelin. Verlag von B. G. Teubner in Leipzig.

Bulletin of the State Normal School, Plattsville, Wisconsin. Course of Study for the Training School. 152 pages. 14.5x22.5 cm. Paper. Board of Regents of Normal Schools.

Francis W. Parker School Yearbook. 186 pages. 15x22.5 cm. Paper. 1915. Francis W. Parker School, Chicago.

Laboratory Experiments as Food Products, by E. H. S. Bailey, University of Kansas. Pages vi+44. 13.5x19.5 cm. Paper. 1915. 25 cents. P. Blakiston's Son & Co., Philadelphia.

Laboratory Manual, by William McPherson and William E. Henderson, Ohio State University. Pages v+141. 14.5x21 cm. Cloth. 1915. 60 cents. Ginn & Company, Boston.

A Laboratory Manual for Work in General Science, by Otis W. Caldwell, W. L. Eikenberry and Charles J. Pieper, the School of Education, University of Chicago. Pages xi+134. 20x27 cm. Cloth. 1915. 50 cents. Ginn & Company, Chicago.

Physik, unter Redaktion von E. Warburg, Charlottenburg. Pages viii+762. 18x26 cm. Cloth. 1914. Verlag von B. G. Teubner in Leipzig und Berlin.

Our Chinese Chances Through Europe's War, by Paul Myron. 220 pages. 11x14 cm. Cloth. 1915. $1.25. Illustrated. Linebarger Brothers, Publishers, Milwaukee, Wis.

Read's Salesmanship, by Harlan E. Reed. 296 pages. 14+20.5 cm. Cloth. 1915. Lyons & Carnahan, Chicago.

Mechanical Drawing, by Joseph Husband, University of Sheffield. 79 pages. 21.5x28 cm. Paper. 1915. 80 cents. Longmans, Green & Co., New York.

Triassic Life of the Connecticut Valley, by Richard S. Lull, Yale University. 285 pages. 14.5x23 cm. Paper. 1915. Published by the State, Hartford.

Mathematics for Machinists, by R. W. Burnham, Erasmus Hall High School, Brooklyn. Pages viii+229. 13x18 cm. Cloth. 1915. John Wiley & Sons, New York.

Elementary Algebra, by Florian Cajori, Colorado College, and Letitia R. Odell, North Side High School, Denver. Pages vii+206. 13x19 cm. Cloth. 1915. The Macmillan Company, New York.

Soils and Plant Life, by J. C. Cunningham and W. H. Lancelot, Iowa State College. Pages xx+348. 13x19 cm. Cloth. 1915. The Macmillan Company, New York.

Analytic Mechanics, by John A. Miller and Scott B. Lilly, Swarthmore College. Pages xv+297. 14.5x21 cm. Cloth. 1915. D. C. Heath & Co., Chicago.

BOOK REVIEWS.

Chemistry in the Home, by Henry T. Weed, B. S., Head of Science Department, Manual Training High School, Brooklyn, N. Y. Pages 385. 2.5x13x19 cm. Illustrated. Cloth. 1915. American Book Co.

Perhaps the strongest feature of this most original little book is the remarkable success of the author in putting the story of chemistry into the language of the child. The book is frankly for pupils in the earlier years of high school, and much of the first part of it could be used with still younger pupils. Many a course in general science would be more successful and more scientific if the chemistry that was included were patterned after the book we are considering.

Of course, much of the theory of chemistry is necessarily omitted on account of the youthfulness of the pupils for whom the book is intended, and such theory as is given is offered as a predetermined matter and not defended or explained. It is merely used as a convenience in order that much material of an informational character may subsequently be presented in a more compact and systematic arrangement.

The author has not hesitated to bring in related sciences wherever their correlation with chemistry will be of service—which is as it should be.

The selection of familiar examples to be used as material on which to build advances is most admirably done. The residua of a city child contain so few things on which to build chemical residua that success in teaching chemistry to city children depends largely on being able to thus call up something from the child's experience that can be related to what is about to be taught.

The later chapters of the book aref ull of information that should be the property of every intelligent adult. Every effort has apparently been made to make this information of use to pupils in connection with personal and social hygiene. The chapter on foods is especially complete and abundantly supplied with tables of dietary values.

The illustrations are numerous and interesting and will help to hold the interest of young pupils.

Those teachers who wish to experiment along the lines of the popular demand of the day and those who have chemistry in the junior years of the high school should examine this text. F. B. W.

Our Chinese Chances Through Europe's War, by Paul Myron. 220 pages. 11x14 cm. Cloth. 1915. Illustrated. $1.25 Linebarger Brothers, Publishers, Milwaukee, Wis.

A book of the times, coming from the press at the psychological moment. Adapted to all American readers, and especially to the American business man, who wishes and has the initiative to push his business into new fields. The intimate knowledge which the author has of the Chinese nation from many points of view has enabled him to present in the book an epitome of the conditions as they exist in that marvelous country. The work is made especially interesting by the narration of many personal experiences by the author himself. The long residence of the author in the Orient has enabled him to make a very critical study of the conditions in China; the facts and conditions presented are therefore fresh and authentic. People desiring to know of the various situations in China today should read this book. It deserves and doubtless will have an extensive sale. C. H. S.

New Plane Geometry, by E. R. Robbins, formerly of Lawrenceville School. Pages viii+264. 14.5x21 cm. 1915. American Book Company, New York.

The author's long experience in teaching geometry, together with suggestions from teachers who have used the old textbook and suggestions from other sources, have made possible a revision which shows many excellent qualities. "It is designed, under good instruction, to develop a clear conception of the geometric idea, and to produce at the end of the course a rational individual and a friend of this particular science." How many of us are teaching boys and girls rather than geometry?

Some of the features which appeal to the writer are: At the beginning pupils not required to prove theorems obviously true; demonstrations begun early after exercises in using compasses and ruler; small letters used to denote lines and angles, hence proof in algebraic form, thus giving considerable application of algebra; an abundance of geometric, numerical and algebraic exercises, all depending for solution on numbered paragraphs only; historical notes, good figures, open page, clear and concise statements.

H. E. C.

Tables and Formulas, Revised Edition, by W. R. Longley, Assistant Professor of Mathematics in the Sheffield Scientific School, Yale University. Pages 37. 13x19 cm. 50 cents. 1915. Ginn & Co., Boston.

This very convenient handbook is intended for use in solving numerical problems in mathematical courses in technical schools and colleges. The tables include four-place common logarithms of numbers to 2,000; four-place trigonometric functions by degrees; radian equivalents of degree measure; natural trigonometric functions for angles in radian measure to 3 radians by .05 of a radian; and squares and cubes, square and cube roots. Twenty pages of formulas include the most important ones in algebra, geometry, trigonometry, analytics and calculus. H. E. C.

Plane Geometry, by J. H. Williams, Head of Department of Mathematics, High School, Urbana, O., and K. P. Williams, Associate Professor of Mathematics in Indiana University. Pages 264. 13.5x19.5 cm. 1915. Lyons & Carnahan, Chicago.

This book is planned to meet the demand for a simplified textbook. The number of propositions is reduced to a minimum, and all proofs are given in complete form. There is a good number of exercises grouped as problems of computation, constructions and theorems; these are said to be carefully graded. At the close of the book fourteen pages are given to the applications of geometry in building and surveying, and forty pages to supplementary exercises and theorems. An appendix gives some historical notes and a brief discussion of parallels. The binding, paper, type and arrangement of material on the page make the book very attractive.

H. E. C.

A Review of High School Mathematics, by Wm. D. Reeve and Raleigh Schorling, Instructors in the University High School of the University of Chicago. Pages x+70. 13.5x20 cm. 40 cents and postage. 1915. The University of Chicago Press.

During three or more years the authors have been testing material for a review course in high school mathematics, and the residual product as given in this book covers the ground of high school mathematics and meets college entrance requirements. It should enable teachers to make their instruction in algebra and geometry a unity which will qualify pupils to solve problems and get results. The problems and exercises are well chosen to give a thorough review of the principles of the two subjects, and are of a nature to interest pupils in the work. The outlines of minimum courses

which are given at the close are very stimulative of thought and offer a basis for the solution of the problem of standardizing high school mathematics. H. E. C.

Repertorium der Physik, Erster Band, Mechanik und Wärme, Erster Teil, by Rudolph H. Weber, Professor in Rostock, and Richard Gans, Professor in Laplata. Pages xii+434. 13x20 cm. M. 8. 1915. B. G. Teubner, Leipsic.

In planning this important work the authors adopted methods of presentation which make these volumes serve purposes somewhat between those of a textbook and a handbook. They contain more material than is ordinarily found in a textbook and give many references to original investigations, but omit in part details of procedure, and condense the proofs. No numerical problems nor computations are given.

The present volume will be of great service as a handbook for students who wish to get at the underlying principles and derivation of formulas, instead of simply looking up a formula to apply in solving problems. It treats of the mechanics of a rigid body, elasticity, hydrodynamics and acoustics. The methods of calculus are used throughout; and the broad scope of the work is clearly shown by the Namenregister, which gives over 275 names, and the index, which covers nine pages in double columns.

H. E. C.

First Course in Chemistry, by William McPherson and William Edwards Henderson, Professors of Chemistry, Ohio State University. Pages x+416. 14x19x2.3 cm. Illustrated. Cloth. 1915. Price, $1.25.

This new chemistry text by the authors of *An Elementary Study of Chemistry* is worthy of consideration by all teachers who are planning a change of text. The method of approach to the subject is more in accordance with the youthfulness of the high school pupil than was the case with the previous book by the same authors. A similar method, if carried out consistently throughout the text, would make an even better text of what is already an excellent one. The subject matter is well related to the affairs of daily life, and many excellent pictures of industrial plants add to this attempt to make chemistry real. F. B. W.

Chemistry, by Georges Darzens, Lecturer at the École Polytechnique, Paris. Pages x+122. 13x19x1.8 cm. Illustrated. Cloth. 1914. Doubleday, Page & Co., N. Y.

This little book is one of the *Thresholds of Science* series. The several numbers were originally published in France and were designed to afford to adults, who had not been able to acquire any knowledge of science in school, some idea of the elements of modern science.

It was also hoped that children who had no other opportunity of learning science might become interested through these books, and thus not grow up in ignorance of the many achievements of this scientific age.

The book is divided into three principal parts. First comes a section dealing with the physical conceptions needed in a study of chemistry, such as states of matter, solution, methods of separating mixtures, etc.

Part two, which is the principal part of the book, gives the fundamentals of general inorganic chemistry.

Part three gives briefly some of the interesting practical applications of chemistry.

The method of presentation is largely the natural method. Description of some experiment precedes the presentation of the principle to be taught, and the description is sufficiently detailed to be used as a laboratory guide to the actual performance of the experiment.

The order of events is good, especially so after the study of water is

begun. The previous attempt to make clear the four types of chemical change—combination, decomposition, replacement and double decomposition—it seems to the reviewer is less well advised, as, while the understanding of these matters makes possible the teaching of much chemistry, yet to give a good understanding with so little of previous achievement in the subject is very difficult.

The method of attack is throughout admirable, and American texts for high school use might well pattern after it. The pupil is not regarded as already familiar with things that he really has not heard of, but is given the necessary information progressively. Another good feature of the book is the skilful manner in which transitions between paragraphs and between chapters are made. There are frequent cross references, and repetition is made use of to clinch important matters. Much preparation is also made, from time to time, for future needs, which is skilful pedagogy.

The section on practical or applied chemistry is full of interesting information and serves to show that chemistry is of real use and not merely an interesting study. The educational value of this part of the book is probably less, in the nature of the case, than that of the first two parts.

For those who cannot have the actual guidance of a skilful teacher in a well-equipped laboratory, with time in which to perform experiments, to write them up in a notebook, to be quizzed as to the meaning of the results and later examined on them and compelled to make use of them, this little book will do all that can be done. F. B. W.

The Boys and Girls of Garden City, by Jean Dawson, Normal School, Cleveland. 12 mo. Cloth. 346 pages. 31 chapters. 130 illustrations. 75c. Ginn & Co., Boston.

The latest and most successful application of encouraging the activity of children in personal and civic hygiene and sanitation. The story is of absorbing interest, and it makes dynamic and concrete the knowledge that a child needs in modern life. The problems of flies, filth, mosquitoes, drinking water, diseases and community life are real to the reader, who is incited to go and do something of like good in his own community. Teachers may gain much from the method employed to obtain results that bring good. The illustrations are of the children who have become interested and who are carrying out the ideas taught. The book is a splendid text for a part of the graded school instruction in hygiene and sanitation. W. M. G.